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APPENDIX E
PART II
QUALITY ASSURANCE PROJECT PLAN
ENVIRONMENTAL CONSERVATION
AND
CHEMICAL CORPORATION (ECC) SITE
ZIONSVILLE, INDIANA

PREPARED FOR:
SETTLING DEFENDANTS

QUALITY ASSURANCE BRANCH

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ENVIRONMENT SERVICES DIVISION

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**ENVIRONMENTAL CONSERVATION
AND
CHEMICAL CORPORATION SITE
ZIONSVILLE, INDIANA**

QUALITY ASSURANCE PROJECT PLAN

Project Manager

USEPA Region V
Remedial Project Manager

Project Quality Control/Quality
Assurance

USEPA Region V
Chief, QA Office

Settling Defendants Chairman

Laboratory Manager

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1.0 PROJECT DESCRIPTION

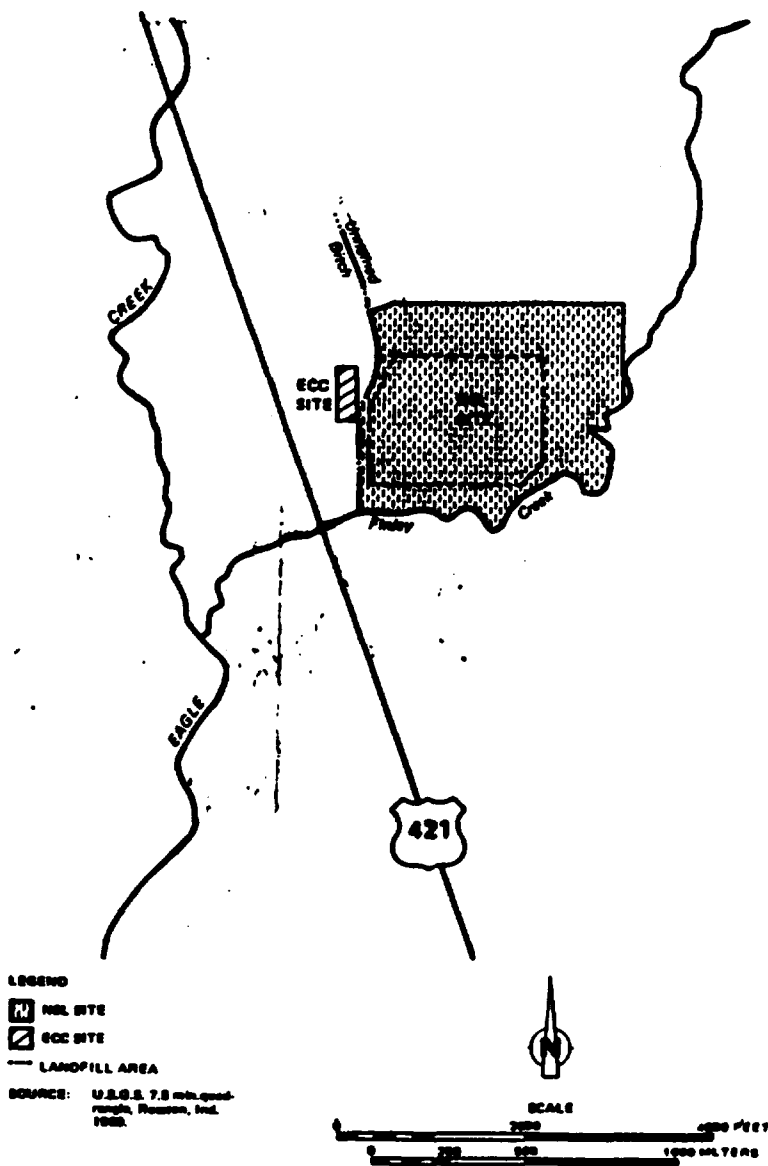
1.1 Introduction

The Environmental Conservation and Chemical Corporation (ECC) Remedial Action activities will include:

- o Soil vapor extraction, concentration and destruction.
- o Soil cover.
- o Access restrictions.
- o Ground water monitoring and surface water monitoring.

1.2 Site Description

The ECC site is located in Boone County, approximately 10 miles northwest of Indianapolis, on US Highway 41 in Zionsville, Indiana (Figure 1-1). The site occupies 6.5 acres west of the Northside Sanitary Landfill (NSL), an operating solid waste disposal facility. The ECC site is bounded on the south and east by NSL landfill property. An unnamed ditch separates the two facilities along the east boundary.



ECC
SITE MAP

FIGURE
1-1

ERM ERM-North Central, Inc.

3/1/89

CS

ECC began operations at the site in 1977 and was engaged in the recovery, reclamation, and brokering of primary solvents, oils and other wastes. Waste products were received in drums and bulk tankers and prepared for subsequent reclamation or disposal. Reclamation processes included distillation, evaporation and fractionation to reclaim solvents and oil.

USEPA investigations into accumulation of contaminated storm water on-site, improper drum inventory, and several spill incidents lead to civil law suits, and finally placement of ECC into receivership in July, 1981. Drum shipments to the site were halted in February, 1982. Surface clean-up activities conducted by USEPA contractors during 1983 and 1984 included removal of cooling pond waters, waste drums, tank waste, contaminated soil, and cooling pond sludge.

A Remedial Investigation/Feasibility Study was conducted by CH2M-Hill for the USEPA and the Record of Decision (ROD) for the site was published on September 25, 1987.

1.3 Remedial Action Plan

Details of the remedial action for the ECC site are presented in this Exhibit A to the Consent Decree for the ECC site and are summarized below.

The Remedial Action Plan (RAP) addresses, in a technically feasible and cost-effective manner, all environmental concerns regarding the site, namely:

- o Direct contact with soils containing volatile organics (VOCs), base neutral/acid organics, and heavy metals;
- o Contamination of ground water by precipitation percolating through soils containing VOCs, base neutral/acid organics, and heavy metals;
- o Contamination of surface waters by overland migration of water in contact with soil containing VOCs, base neutral/acid organics, and heavy metals;
- o Ingestion of ground water containing VOCs, base neutral/acid organics, and heavy metals; and
- o Contamination of surface waters by discharge of ground water containing VOCs, base neutral/acid organics and heavy metals.

Additionally, the RAP complies with the Superfund Amendments and Reauthorization Act (SARA) of 1986 by treating the contaminants at ECC so that they do not present any current or currently foreseeable future risk to health or the environment.

The RAP which is described in detail in the following sections includes the components listed below:

- o Soil vapor extraction, concentration, and destruction;
- o Installation of a RCRA-compliant cover;
- o Establish access restrictions; and
- o Ground water and surface water monitoring.

The intent of this RAP is to provide for the implementation of a comprehensive remedy that will remediate the site and will constitute "clean closure" by removing and destroying wastes at the site so as to preclude any risk to human health and the environment through any media (air, soil, surface water, or ground water). The soil vapor extraction system to be implemented under this Document will result in a cleanup level for constituents of concern in the site soils so as to obviate the need for ground water interception/collection systems at the site. Specifically, the soil vapor extraction system has been designed and will be operated to achieve Cleanup Standards (as specified in Table 3-1 of Exhibit A) in the soil as well as in the ground and surface water at the site that will protect human health and the environment.

Design of the vapor extraction system in the area beneath the concrete slab and placement of the RCRA-compliant cover over the site in advance of the vapor extraction process will prevent the

infiltration of water beneath the concrete slab and migration through the subbase of the concrete slab.

Surface water and ground water sampling will be conducted during and after the operation of vapor extraction systems to verify the effectiveness of the RAP.

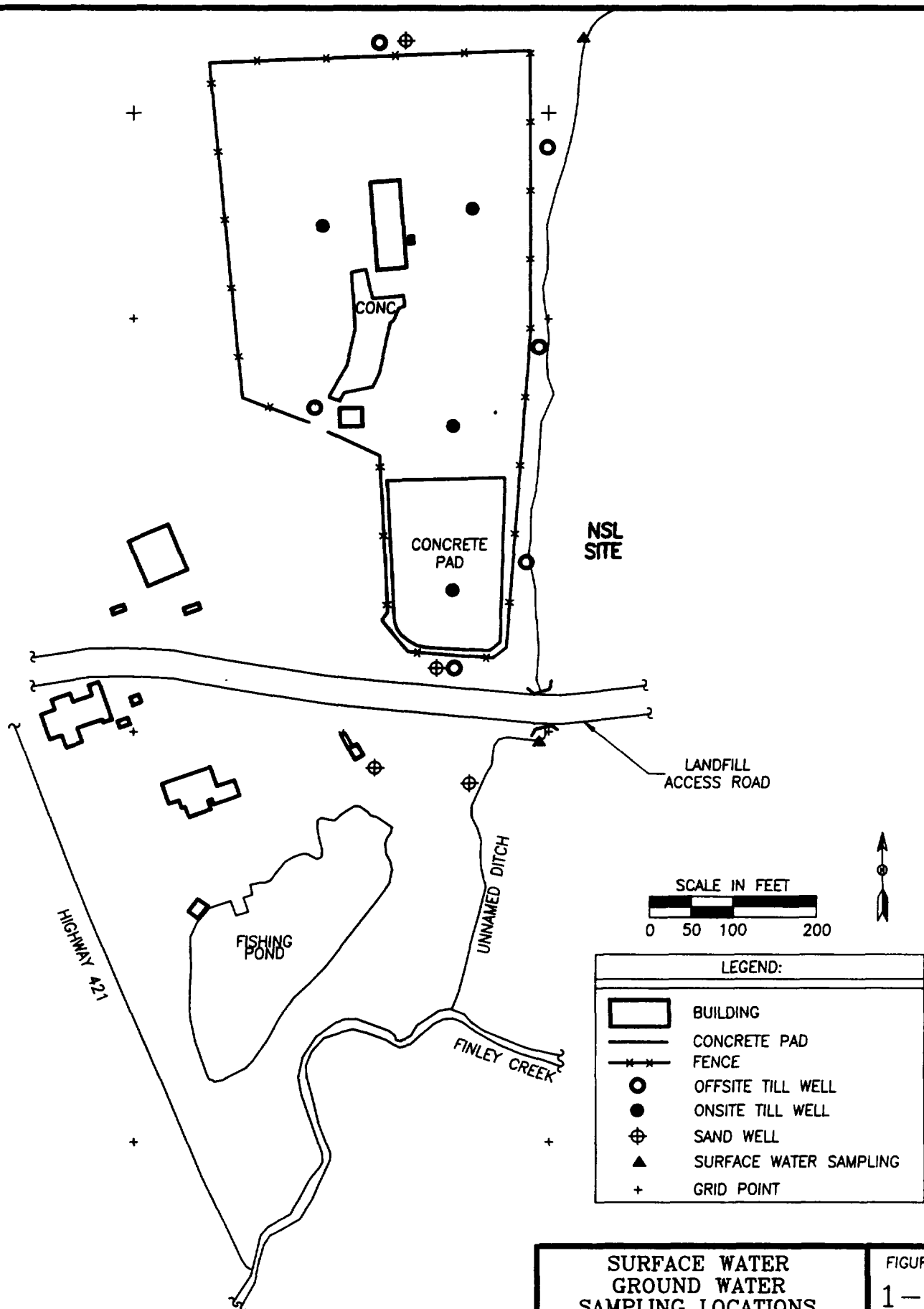
The components of the RAP as presented herein are compatible with the proposed remedy for the adjacent Northside Sanitary Landfill (NSL) site. As the remedial design is finalized for the NSL site, the respective RAPs for ECC and NSL be reviewed to ensure compatibility of design and construction schedules for each system.

1.4 Sample Network and Rationale

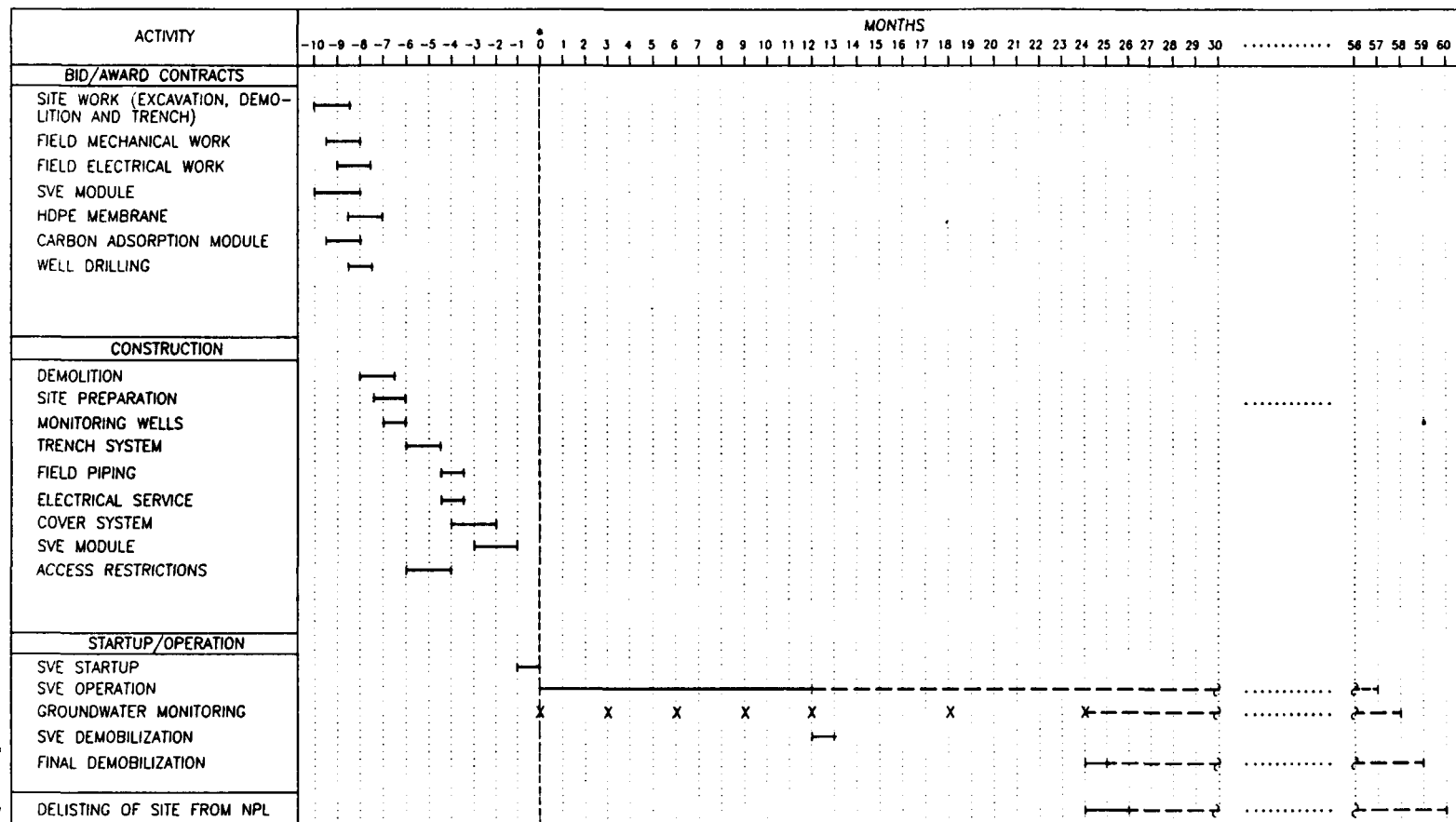
The locations of the monitoring wells and surface water monitoring points are shown on Figure 1-2. The monitoring well locations were selected based on data obtained during the Remedial Investigation which indicate that ground water flow from the ECC site is in the southern direction.

1.5 Project Schedule

The anticipated schedule for completion of the Remedial Action at the ECC site is presented in Figure 1-3.



ERM ERM-North Central, Inc.	FIGURE
	1-2
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NOTES:

SVE  SOIL VAPOR EXTRACTION

- MONTH "0" CORRESPONDS TO THE DATE THE NSL PIPELINE IS AVAILABLE FOR ECC USE
- SVE SYSTEM OPERATION IS PLANNED FOR 12 MOS. BUT MAY BE EXTENDED IF NECESSARY TO ACHIEVE CLEANUP STANDARDS
- FINAL DEMOBILIZATION AND DELISTING ACTIVITIES WILL OCCUR ONCE CLEANUP STANDARDS HAVE BEEN ACHIEVED & VERIFIED.

ECC SITE
ESTIMATED REMEDIAL ACTION
IMPLEMENTATION SCHEDULE



ERM-North Central, Inc.

FIGURE NO.

1-3

3/8/89

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2.0 PROJECT ORGANIZATION AND RESPONSIBILITY

The primary contractor to the ECC Settling Defendants, will have overall responsibility for all phases of the ECC Remedial Action activities.

2.1 Management

Operational responsibilities including execution and direct management of the technical and the administrative aspects of this project will be assigned as follows:

Settling Defendants' Coordinator

Remedial Project Manager
Settling Defendants' Contractor

Remedial Project Manager
USEPA, Region V

2.2 Field Activity

The Settling Defendants' chosen contractor will supervise all Remedial Action field activities.

2.3 Laboratory Analysis

A laboratory which participates in USEPA's Contract Laboratory Program (CLP), will perform all chemical analyses required as part of the Remedial Action activities.

2.4 Quality Assurance

Overall Quality Assurance (QA) responsibility will be held by the Quality Assurance Officer (QAO) of the Settling Defendants' chosen contractor. All subcontractors will provide appropriate project management, and the Settling Defendants' contractor will furnish administrative oversight and Quality Assurance/Quality Control (QA/QC) for all deliverables. The Quality Assurance Office of the USEPA, Region V will provide review of the QAPP.

2.5 Performance and System Audits

Performance and system audits for field operations will be performed by the Settling Defendants' contractor QAO. The Contract Project Management Section of the Central Regional Laboratory of USEPA Region V will be responsible for performance and system audits of the analytical laboratory.

3.0 QUALITY ASSURANCE OBJECTIVES

The overall quality assurance objective is to develop and implement procedures for sampling, laboratory analyses, field measurement, and reporting that will provide data to a degree of quality consistent with its intended use and defensible in a court of law. This section defines the goals for levels of QC effort and the accuracy, precision, sensitivity, completeness, representativeness, and comparability of laboratory analyses.

3.1 Level of QC Effort

Quality Control samples, including collocated or replicate samples, and field and trip blanks, will be submitted to the analytical laboratory to assess the quality of the data resulting from field sampling activities. Collocated samples provide intra-laboratory precision information for the entire measurement system. Trip blanks which will be kept with samples throughout the sampling event, will be analyzed to check for procedural contamination of samples that occur during shipping. Field blanks will be used to determine if decontamination procedures have been sufficient.

Guidelines for collocated or field replicate samples for the Remedial Action activities will be one collocated or replicate sample for each group of 10 or fewer investigative samples. One field blank will be collected for each group of 10 or fewer investigative samples. Trip blanks, one per shipping container, will only be provided for water samples. This specific level of QC effort is summarized in Table 3-1. The analytical laboratory

selected for sample analyses will be a participant in the USEPA Contract Laboratory Program (CLP) for organic and inorganic testing. The level of QC effort provided by the laboratory will be equivalent to the level of QC effort specified under the 7/87 Statement of Work (SOW) for Inorganics and the 7/87 SOW for Organics.

The level of QC effort for field measurement of ambient air with an HNu photoionization meter will consist of initial and continuing calibration verification using a standard reference gas.

3.2 Accuracy, Precision, and Sensitivity of Analyses

The QA objectives of analyses with respect to accuracy, precision, and sensitivity are to achieve acceptable data based on specified performance criteria. Accuracy and precision requirements and method detection limits for CLP protocol analyses are described in the 7/87 SOW for Inorganics and the 7/87 SOW for Organics for the CLP Program.

Analytical accuracy will be assessed through the collection of organic samples for matrix spike/matrix spike duplicate and surrogate spike analyses. A matrix effect is a phenomenon that occurs when other sample components interfere with the analysis of the contaminants of interest. Percentage recovery information obtained from matrix spikes will be used to address the amount of bias present in the measurement system (accuracy). In addition, surrogate spike recovery will be evaluated by determining whether the concentrations (measured as percent recovery) falls inside

the contract required recovery limits. This surrogate spike recovery information will be used to indicate the systematic error in the analytical method. If recovery of any one surrogate compound falls outside of the contract surrogate spike recovery limits, the laboratory must take appropriate actions in accordance with the 8/87 SOW for the CLP program to ensure accuracy of the analytical method. For metals analysis, interference check samples must be run to ensure accuracy in the analytical method.

The accuracy of the HNu photoionization meter will be assured by daily calibration verification with check standards. If readings vary more than 5% from an expected value, the unit will be replaced.

3.2.1 Data Completeness, Representativeness, and Comparability

It is expected that the CLP organic and inorganic parameters in Table 7-1 analyzed consistent with the CLP procedures will provide data meeting the QC acceptance criteria for 95% of all samples analyzed. Upon request, the completeness of an analyses will be documented by the laboratory with items such as chromatograms, spectra, and QC data to allow the data user to assess the quality of the results.

The sampling and analyses program is designed to provide data representative of site conditions for conducting and evaluating the effectiveness of the RAP. During the development of this program, special consideration was given to existing analytical results from previous site investigations, and the physical setting of the site to ensure the representativeness of the data generated by the Remedial Action activities.

Data comparability will be assured by the use of duplicate and blank samples for field QC and by the specific laboratory QA/QC activities required by the CLP protocol.

3.2.2 Documentation

The documentation system will comply with the requirement of CLP protocol.

3.2.3 Quality Control Requirements

The sampling activities will include the following procedures for the purpose of Quality Control:

- o Collection of field duplicates, including collocated and replicate samples.
- o Collection of field blanks.
- o Inclusion of trip blanks in sample shipments.

The specific level of QC effort is summarized in Table 3-1.

TABLE 3-1
INVESTIGATIVE AND QUALITY ASSURANCE SAMPLING EFFORT

Sample Matrix	Laboratory Parameters	Investigative Samples			QA Samples						Matrix Total
		Duration (week)	Freq.	Total	Replicate			Field Blank			
					No.	Freq.	Total	No.	Freq.	Total	
Extracted Vapor	Organics in Table 7-1	1	1/day	7	1	1	1	1	1	1	9
		2-5	1/wk	4	1	1	1	1	1	1	6
		6-*	1/mo	--	--	--	--	--	--	--	--
Water Collected from Soil Vapor Extraction	Volatile Organics in Table 7-1	**	**	--	--	--	--	--	--	--	--
	Base Neutral Organic and Acid Extractable Organics in Table 7-1										
	PCBs										
	Metals in Table 7-1										
	Cyanide										
Ground Water (on-site and off-site wells)	Volatile Organics in Table 7-1 (year)	1	4/yr	56	2	4	8	2	4	8	72
	T.C.L. Base Neutral Organic and Acid Extractable Organics in Table 7-1	2-***	2/yr	--	--	--	--	--	--	--	--
	PCBs										
	Metals in Table 7-1										
Surface Water	Volatile Organics in Table 7-1	1	4/yr	8	1	4	4	1	4	4	16
	T.C.L. Base Neutral Organic and Acid Extractable Organics in Table 7-1	2-***	2/yr	--	--	--	--	--	--	--	--
	PCBs										
	Metals in Table 7-1										
	Cyanide										

* Monitoring to be conducted during operation of the soil vapor extraction system.

** Monitoring program will be implemented according to the requirements of the off-site handling/treatment facility.

*** Monitoring to be terminated in accordance with Section 2.1.4 of Exhibit A.

4.0 SAMPLING PLAN

The Field Sampling Plan (FSP), presented as Part I of this Sampling and Analysis Plan, contains all appropriate information pertinent to field sampling procedures. A summary of the sampling schedule is presented in Table 4-1.

TABLE 4-1
REMEDIAL ACTION TASKS SAMPLING SCHEDULE

<u>Activity</u>	<u>Sample Matrix</u>	<u>Sample Frequency</u>	<u>Laboratory Analyses</u>
Soil vapor extraction, Concentration and destruction	Extracted Vapor	Daily during first week; weekly for 4 following weeks, monthly thereafter during operation of the soil vapor extraction system	Volatile Organics in Table 7-1
	Water Collected	Monitoring Program will be implemented according to the off-site handling/treatment facility requirements	Volatile Organics in Table 7-1 Base Neutral Organics and Acid Extractable Organics in Table 7-1 Metals in Table 7-1 Cyanide
Soil Cover	No sampling required		
Access restrictions	No sampling required		
Ground water monitoring (on-site and off-site wells) and surface water monitoring	Ground Water Surface Water	Quarterly for 1 year; semi- annually thereafter until terminated in accordance with Section 2.1.4 of Exhibit A.	Volatile Organics in Table 7-1 Base Neutral Organics and Acid Extractable Organics in Table 7-1 PCBs Metals in Table 7-1 Cyanide

5.0 SAMPLE CUSTODY PROCEDURES

Sample custody procedures will be consistent with Attachment 4 of the USEPA Region V Guidance, "Content Requirements for Quality Assurance Project Plan."

A sample will be considered under the person's custody if: (1) it is in a person's physical possession; (2) it is in view of the person after he/she has taken possession; (3) it has been secured by that person so that no one can tamper with the sample, or (4) it has been secured by that person in an area that is restricted to authorized personnel.

The sample packaging and shipment procedures summarized below will ensure that the samples will arrive at the laboratory with the chain-of-custody intact.

Field procedures are as follows:

- o The field sampler will be personally responsible for the care and custody of the samples until they are transferred or properly dispatched. As few people as possible will handle the samples.
- o All samples will be tagged with sample numbers and locations.

- o Sample tags will be completed for each sample using waterproof ink unless prohibited by weather conditions.

Transfer of custody and shipment procedures will be as follows:

- o Samples will be accompanied by a properly completed chain-of-custody form. The sample numbers and locations will be listed on the chain-of-custody form. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date and note the time on the records. This record documents the transfer of custody of samples from the sampler to another person, to a permanent laboratory, or to/from a secure storage area.
- o Samples will be properly packaged for shipment and dispatched to the appropriate laboratory for analysis, with a separate signed custody record enclosed in each sample box or cooler. Shipping containers will be secured with strapping tape and custody seals for shipment to the laboratory.

- o A sample analysis request form will accompany each shipment of samples to the analytical laboratory. A description of the requested analysis and the specific laboratory analysis code will be included on this form.
- o A standardized sample tracking form will also be completed to establish sample custody prior to shipment to the laboratory and to document specific sample preservation methods.

Copies of all sample custody forms will be maintained in the project files along with copies of all field measurement data and sample-specific information recorded in the field log book and on field data forms.

The specifications for chain-of-custody and document control for the laboratories will comply with the CLP requirements and be carried out in accordance with the 7/87 SOW for Inorganics and 7/87 SOW for Organics for CLP analyses.

The chosen laboratories will provide all sample containers necessary for field sampling and QC requirements. Each lot of sample containers will be checked for cleanliness by the laboratory and sealed to prevent contamination. Samples will be received at the laboratory by the sample custodian, who will examine each sample to ensure that no damage occurred during shipment and that the chain-of-custody record is complete and

accurate. The sample custodian will also ensure that each sample has been preserved in a manner required by the particular test and stored according to the correct procedure. Samples will be preserved by storage in a cooler maintained at 4°C until the analyses begin.

The Settling Defendants' contractor will maintain the Remedial Action files along with all relevant records, reports, logs, field notebooks, pictures, subcontractor reports, and data reviews in a secured, limited access area and under the custody of the site manager.

6.0 CALIBRATION PROCEDURES AND FREQUENCY

This section presents the calibration procedures and information for all major measurement systems including field and analytical laboratory testing.

6.1 Field Instruments

A maintenance and calibration program will be implemented to ensure that routine calibration and maintenance are performed on all field instruments. The program will be administered by the field team leader who will perform routine preventative maintenance on a weekly basis and calibration of field instruments on a daily basis. The HNu photoionization meter will be calibrated using 100 ppm isobutylene (a standard reference gas).

Field personnel will be familiar with the calibration, operation, and maintenance of all field instruments and will maintain their proficiency. If field equipment should fail, the field team leader will be contacted immediately and will either provide replacement equipment or have the malfunction repaired immediately.

6.2 Laboratory Equipment

The laboratories will perform calibration and preventative maintenance procedures for laboratory equipment in accordance with the 7/87 SOW for Inorganics and the 7/87 SOW for Organics for the CLP Program.

7.0 ANALYTICAL PROCEDURES

Water samples collected will be analyzed for organic and inorganic parameters in Table 7-1 consistent with CLP procedures. The CLP analyses will be conducted by the laboratory using methods specified in the 7/87 SOW for Inorganics and the 7/87 SOW for Organics for CLP laboratories. If high-level dilution of samples is required such that certain constituents may be diluted below their respective method detection limits, the laboratory will be consulted to explore methods of detecting all constituents. All chosen methods will be in accordance with those specified in the 7/87 SOW for Inorganics and the 7/87 SOW for Organics for CLP laboratories.

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TABLE 7-1

CLP TARGET COMPOUND LIST (TCL) AND
CONTRACT REQUIRED QUANTITATION LIMITS (CRQL)^(1,2)

I.	Volatiles	CAS Number	Quantitation Limits ⁽³⁾	
			Water ug/l	Low Soil/Sediment ⁽⁴⁾ ug/kg
✓1.	Methylene Chloride	75-09-2	5	5
✓2.	Acetone	67-64-1	10	10
✓3.	1,1-Dichloroethene	75-35-4	5	5
✓4.	1,1-Dichloroethane	75-34-3	5	5
✓5.	Chloroform	67-66-3	5	5
✓6.	2-Butanone	78-93-3	10	10
✓7.	1,1,1-Trichloroethane	71-55-6	5	5
✓8.	1,1,2-Trichloroethane	79-00-5	5	5
✓9.	4-Methyl-2-pentanone	108-10-1	10	10
✓10.	Tetrachloroethene	127-18-4	5	5
✓11.	Toluene	108-88-3	5	5
✓12.	Chlorobenzene	108-90-7	5	5
✓13.	Ethyl Benzene	100-41-4	5	5
✓14.	Xylenes (Total)	1330-20-7	5	5

(1) 7/87 SOW for CLP Program.

(2) Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

(3) Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

(4) Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for Volatile TCL Compounds are 125 times the individual Low Soil/Sediment CRQL.

TABLE 7-1

CLP TARGET COMPOUND LIST (TCL) AND
CONTRACT REQUIRED QUANTITATION LIMITS (CRQL)^(1,2)

II. Semi-Volatiles	CAS Number	Quantitation Limits ⁽³⁾	
		Water	Low Soil/Sediment ⁽⁴⁾
		ug/l	ug/kg
~15. Phenol	108-95-2	10	330
✓16. Isophorone	78-59-1	10	330
✓17. Napthalene	91-20-3	10	330
✓18. 4-Chloroaniline	106-47-8	10	330
✓19. Diethyl phthalate	84-66-2	10	330
✓20. Di-n-butyl phthalate	84-74-2	10	330
✓21. bis(2-Ethylhexyl)phthalate	117-81-7	10	330

(1) Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

(2) Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for Semi-Volatile TCL Compounds are 60 times the individual Low Soil/Sediment CRQL.

TABLE 7-1

CLP TARGET COMPOUND LIST (TCL) AND
CONTRACT REQUIRED QUANTITATION LIMITS (CRQL)^(1,2)

III. PCB	CAS Number	Quantitation Limits ⁽³⁾	
		Water ug/l	Low Soil/Sediment ⁽⁴⁾ ug/kg
✓ 22. Aroclor-1016	12674-11-2	0.5	80.0
✓ 23. Aroclor-1221	11104-28-2	0.5	80.0
✓ 24. Aroclor-1232	11141-16-5	0.5	80.0
✓ 25. Aroclor-1242	53469-21-9	0.5	80.0
✓ 26. Aroclor-1248	12672-29-6	0.5	80.0
✓ 27. Aroclor-1254	11097-69-1	1.0	160.0
✓ 27. Aroclor-1260	11096-82-5	1.0	160.0

(1) Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

(2) Medium Soil/Sediment Contract Required Quantitation Limits (CRQL) for Pesticide/PCB TCL compounds are 15 times the individual Low Soil/Sediment CRQL.

TABLE 7-1

IV.	T.A.L. Inorganics	Quantitation Limit (1,2)
		ug/l
✓1.	Antimony	60
✓2.	Arsenic	10
✓3.	Barium	200
✓4.	Beryllium	5
✓5.	Cadmium	5
✓6.	Chromium	10
✓7.	Lead	5
✓8.	Manganese	15
✓9.	Mercury	0.2
✓10.	Nickel	40
✓11.	Silver	10
✓12.	Vanadium	50
✓13.	Zinc	20
✓14.	Cyanide	10
✓15.	Tin	

(1) Elements determined by inductively coupled plasma emission or Atomic Absorption (AA) spectroscopy.

(2) Quantitation limits for water.

8.0 INTERNAL QUALITY CONTROL CHECKS

8.1 Analytical Laboratories

Quality Control at the Settling Defendants' chosen laboratories will be carried out in accordance with the 7/87 SOW for Inorganics and the 7/87 SOW for Organics for CLP laboratories.

8.2 Field Quality Control

Field Quality Control will be carried out by an experienced geologist or engineer during all field activities. The on-site supervisor will be present during all sampling activities and subcontracted activities. All field QC procedures, as discussed in Section 3.1, will be carried out according to the QAPP and documented in the field notebook.

9.0 DATA REDUCTION, VALIDATION AND REPORTING

Procedures for documenting sample collection and custody, validating analytical data, and reporting the results of each phase of the Remedial Action activities are covered in this section.

9.1 Documentation

Information pertaining to sample collection, sample custody, analyses to be performed, field measurements, and other field observations will be documented and stored.

Field measurements and sample collection data will be recorded on specific field data forms and in a field log book. Sample custody and requests for analytical tests to be performed will be documented on sample tracking forms, chain-of-custody records, and sample analysis request forms.

Data received from the analytical laboratories will be validated, organized under specific project headings, and stored in the project files maintained at the Settling Defendants' contractor offices.

9.2 Data Validation

The Settling Defendants' chosen laboratories will perform in-house analytical data reduction and validation under the direction of the respective laboratory QA officers. The laboratory review will include checks for the attainment of QC

criteria as outlined in CLP procedures and established USEPA methods. The validity of analytical data will also be assessed by comparing the analytical results of replicate and blank samples.

Additionally, the laboratories will critique their own analytical programs by using spiked addition recoveries, established detection limits, precision and accuracy control charts and by keeping accurate records of the calibration instruments.

The Settling Defendants' chosen contractor will review all sample collection procedures and laboratory data validations to ensure that QA/QC has been maintained. The data validation analysis will be conducted in accordance with USEPA guidance documentation such as "Laboratory Data Validation Function of Guidelines" (July, 1988 for Inorganics and February, 1988 for Organics).

9.3 Reporting

Results from the data validation and QA/QC analysis will be summarized in technical memoranda for submittal to the USEPA and Indiana Department of Environmental Management (IDEM). All data, qualified or unqualified, will be presented in technical memoranda as tables or supporting appendices for the memoranda. Interpretative or summary data sets will be provided in addition to the complete data set. All laboratory reports and verification calculations for QA/QC will be prepared in accordance with the 7/87 SOW for Inorganics and the 7/87 SOW for Organics and will be retained for USEPA audit and review. All site investigation data will be analyzed, and a summary

interpretation will be developed for the type and extent of contamination from the site.

9.4 Data Package/Data Deliverables

The Settling Defendants' chosen laboratories will provide the standard CLP data package required under the appropriate SOWs. This information will be presented in a CLP format including a case narrative, surrogate spike recoveries, all recoveries, matrix spike/spike duplicate recoveries, summary of method blanks, GC run time chronology and order, sample results and all raw data for method blanks.

10.0 PERFORMANCE AND SYSTEM AUDITS

The Settling Defendants' contractor project Quality Assurance officer will monitor and audit the performance of QA/QC procedures to ensure that Remedial Action activities are executed in accordance with this QAPP.

10.1 Laboratory

All laboratory external and system audits will be carried out by the Region V Central Regional Laboratory (CRL).

10.2 Field Activities

QA audits of field measurements procedures, sample collection, sample custody procedures, and monitoring well installation will be conducted on a periodic basis to document that field activities are performed in accordance with the Field Sampling Plan. These audits will be scheduled to allow oversight of as many field activities as possible and will be performed by the contractor field team leader.

11.0 PREVENTATIVE MAINTENANCE

11.1 Laboratory Equipment

All equipment at the laboratories will be maintained in accordance with 7/87 SOW for Inorganics and the 7/87 SOW for Organics for CLP laboratories.

11.2 Field Equipment

Preventative maintenance procedures for the HNu photoionization meter, pH meter, and conductivity meter will be carried out in accordance with the operating manual for the instrument.

**12.0 SPECIFIC ROUTINE PROCEDURES USED TO ASSESS DATA PRECISION,
ACCURACY AND COMPLETENESS**

The Settling Defendants' chosen CLP laboratories will comply with the 7/87 SOW for Inorganics and the 7/87 SOW for Organics for CLP laboratories to assess data precision, accuracy and completeness.

13.0 CORRECTIVE ACTION

13.1 Analytical Laboratories

Corrective actions for the Settling Defendants' chosen CLP laboratories will be carried out in accordance with procedures outlined in the 7/87 SOW for Inorganics and the 7/87 SOW for Organics for CLP laboratories.

13.2 Field Work

Corrective action indicated by audit results or detection of unacceptable data will be determined by the Settling Defendants' Project Manager in consultation with the ECC Settling Defendants, USEPA, and IDEM. Corrective action may include, but is not limited to:

- o Reanalyzing samples if holding time criteria are not exceeded.
- o Resampling and analyzing site areas in question.
- o Evaluating and amending sampling and analytical procedures.
- o Accepting data with an acknowledged level of uncertainty.

- o Eliminating outliers identified by the validation task.

The proposed corrective action will be implemented only after full agreement to the type of action required by the Regulatory Agencies and the ECC Settling Defendants is achieved.

14.0 QUALITY ASSURANCE REPORTS

Quality Assurance reports will be issued by the Settling Defendants' chosen contractor as part of the Remedial Action Technical Memoranda. These reports will include the results of QA audits and any necessary corrective action procedures. In addition, the data validation and data sufficiency task will be incorporated into the technical memoranda.

REFERENCES

USEPA, 1980, Guidelines and Specifications for Preparing Quality Assurance Project Plans, QAMS-005/80, Washington, D.C., December 29.

USEPA, 1988, Laboratory Data Validation Functional Guidelines.

USEPA, Updated, Content Requirements for Quality Assurance Project Plan, Draft Copy, Dr. Chen-Wen Tsai, Region V.

ATTACHMENT A

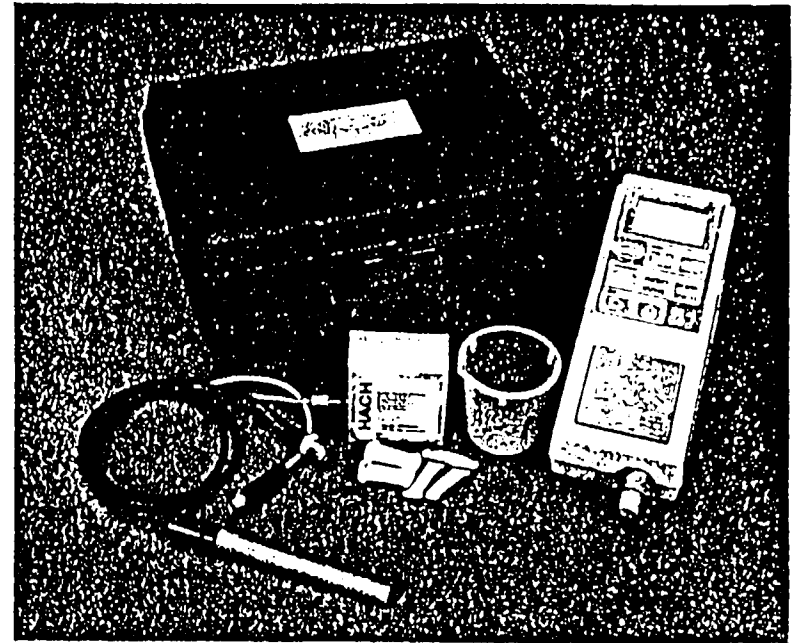
INSTRUCTION MANUAL
PORTABLE HACH ONE
pH METER

MODEL 43800-00

MANUAL
MANUAL



HACH COMPANY



Model 43800-00 Portable Hach One pH Meter

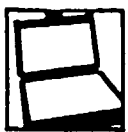



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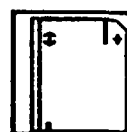



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ILLUSTRATIONS

Front	Model 43800-00 Hach One pH Meter
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SAFETY PRECAUTIONS

Before attempting to unpack, set up or operate this instrument, please read this entire manual. Pay particular attention to all warnings, cautions and notes. Failure to do so could result in serious injury to the operator or damage to the equipment.

USE OF WARNINGS, CAUTIONS AND NOTES

Warnings, cautions and notes used in this manual have the following significance:

WARNING

Failure to observe this information can result in personal injury or loss of life.

CAUTION

Failure to observe this information can result in damage to equipment.

Note

Information that requires special emphasis



METER SPECIFICATIONS—MODEL 43800-00

RANGE

pH	-1.99 to 19.99 pH
millivolts	0 to ± 1999 mV
temperature	-5 to 105°C

RELATIVE ACCURACY

pH	± 0.01 pH
millivolts	$\pm 0.10\%$ of reading ± 0.2 mV
temperature	$\pm 0.5^\circ$ C

RESOLUTION

pH	0.01 pH
millivolts	0.1 mV (0 to ± 999.9 mV) 1 mV (± 1000 mV to ± 1999 mV)
temperature	0.1° C

INPUT IMPEDANCE

10^{12} ohms

TEMPERATURE STORAGE RANGE

-40° C to 60° C (Electrode stored dry)

OPERATING TEMPERATURE RANGE

0 to 50° C

TEMPERATURE COMPENSATION RANGE

Measurements in pH Mode -5°C to 105°C

Automatic Buffer Recognition Calibration Mode 0°C to 60°C

OPERATING HUMIDITY

0 to 90% relative humidity, noncondensing

POWER SAVE FEATURE

The instrument powers down if a key has not been pressed within six minutes.

ELECTRODE

Model 44200-51 Hach One pH Electrode with Ag/AgCl Reference and Temperature Sensor; with BNC connector

POWER REQUIREMENTS

6 Volt J Battery

BATTERY LIFE

More than 40 hours under continuous use

SIZE

23L x 9W x 7cmH (9 x 3-1/2 x 2-1/2")

SHIPPING WEIGHT

1.8 kg (4 lbs)

(Subject to change without notice.)



ELECTRODE SPECIFICATIONS—MODEL 44200-51

RANGE

0-14 pH units

ISOPOTENTIAL POINT

7 ± 0.2 pH

ELECTRODE RESISTANCE

Less than 100 megohms at 25° C (new)

TEMPERATURE RANGE

Continuous Use 0 to 45° C (32 to 113°F)

Intermittent Use 0 to 100° C (32 to 212°F)

Storage -40 to 60° C (-40 to 140°F)

REFERENCE ELEMENT

Silver/Silver Chloride

ELECTRODE DIAMETER

10.5 mm (0.41")

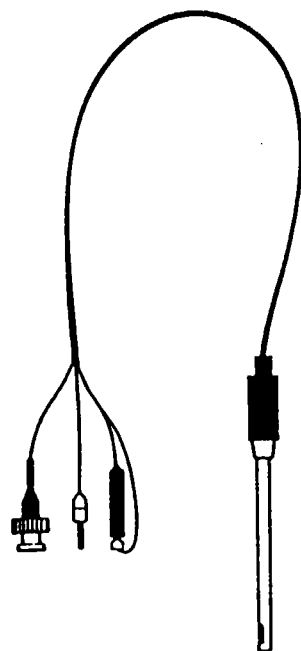
ELECTRODE LENGTH

14 cm (5.5")

CABLE LENGTH

91.5 cm (36")

(Subject to change without notice.)



QUICK START INSTRUCTIONS

The manual has complete instructions on preparing for use, calibration and measurement. Below is an outline of these instructions. Additional information may be found on the pages in parentheses.

INSTALLATION

1. Install battery. (12)
2. Install cartridge. (13)
3. Connect electrode. (15)
4. Turn the Priming Knob counterclockwise five complete turns.

SAMPLE MEASUREMENT (26)

1. Open the pH 4.01 Hach Powder Pillow Buffer (red) with the clip-pers provided. Dissolve the contents in 50 mL deionized water using the included beaker. To stir the solution use the electrode. Rinse the electrode with deionized water after use.
2. Open the pH 7.00 Hach Powder Pillow Buffer (yellow) with the clip-pers provided. Dissolve the contents in 50 mL deionized water using the other beaker. To stir the solution use the electrode. Rinse the electrode with deionized water after use.

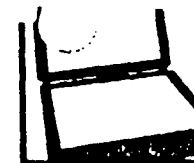
(The buffers may be poured into a drain with running water when no longer needed.)



3. Press: The display will light. If wrong keys are pressed, etc., at any time during a sequence of steps, press to turn off the meter and start over with this step.

(The meter will go blank if a key is not pressed during a six-minute interval.)

(A detailed key description is found on pages 18 to 23.)

4. Press:
5. Press: The Auto indicator will light. Calibration in the automatic buffer recognition mode has been started.
6. Place the electrode into the pH 4.01 Hach Powder Pillow Buffer and press the Dispenser Button until it clicks.



7. Press:  and wait until the pH indicator stops flashing. The actual pH will appear in the display. If the solution temperature deviates from 25°C, the display will show the actual pH and not the labeled pH value.
8. Rinse the electrode, and repeat Steps 6 to 7 with the pH 7.00 Hach Powder Pillow Buffer.
9. Press:  The meter is now measuring pH.
10. Rinse the electrode with deionized water and place into the unknown sample. Press the Dispenser Button until it clicks. The display will show the sample pH.

DIAGNOSTIC MESSAGES

A more complete description of the error codes is found on page 50.

- E 1** The probe voltage reading is out of range in the pH mode.
- E 2** The deviation from the ideal pH slope of -59.2 mV/pH unit is greater than 30%.
- E 3** The probe mV offset is greater than 120 mV or less than -120 mV.
- E 4** The pH reading has not been recognized as one of the 4.01, 7.00 or 10.00 pH standards in the automatic buffer recognition mode.
- E 5** Both calibration solutions have the same nominal pH value.
- E 6** The voltage is less than -50 mV or greater than +50 mV while the millivolt mode is being zeroed.
- E 7** The temperature is out of autocalibration range, 0 to 60 °C.
- E 8** The millivolt reading is out of range, less than -1999 mV or greater than +1999 mV.

Prompting indicators are described on page 48.

A troubleshooting guide is found on page 52.

PART 1. PREPARATION FOR USE UNPACKING

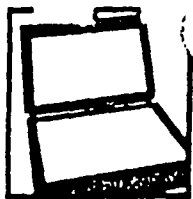
Remove the instrument and accessories from the shipping container and inspect each item for any damage that may have occurred during shipping. Verify that the following items are present:

Model 43800-00 Portable Hach One pH Meter
Model 44200-51 Combination pH Electrode with built-in Temperature Sensor
Beaker, 100 mL (2)
Battery, 6 volt, J type
Buffer Powder Pillows, pH 4.01 (red) and pH 7.00 (yellow)
Hach One Reference Electrode Solution Cartridge
Instruction Manual
Clipper, Large
Carrying Case

In addition to the accessories listed above, several items of optional equipment and apparatus are available from Hach; see Replacement Parts and Accessories, Part 5.

If any items are missing or damaged, please write or call the Hach Factory Service Center, Ames, Iowa, for instructions. Do not return the instrument without prior authorization. The toll-free number is 800-247-3990.

If you are located in Canada, Latin America, the Caribbean, the Far East or the Pacific Basin, please contact Hach Company, World Headquarters, P.O. Box 389, Loveland, Colorado 80539 U.S.A. Telephone (303) 669-3050, TWX (Telex) 910-930-9038. Customers located in Europe, the Middle East or Near East, or in Africa, please contact Hach Europe, S.A./N.V., B.P. 51, B 5000 Namur 1, Belgium. Telephone (081) 44.53.81, Telex 846-59027.



ASSEMBLY

Complete the following steps (Battery, Cartridge and Electrode Installation) to assemble the Hach One pH Meter.

BATTERY INSTALLATION

The 6-volt J battery supplied with the instrument must be installed. To install, remove from the plastic package and remove the battery cover from the bottom of the instrument.

Align the battery as shown in Figure 1. Slide the terminal end in first towards the contacts.

Equivalent replacement batteries are:

Duracell #7K67

Varta #4018T

Eveready #539

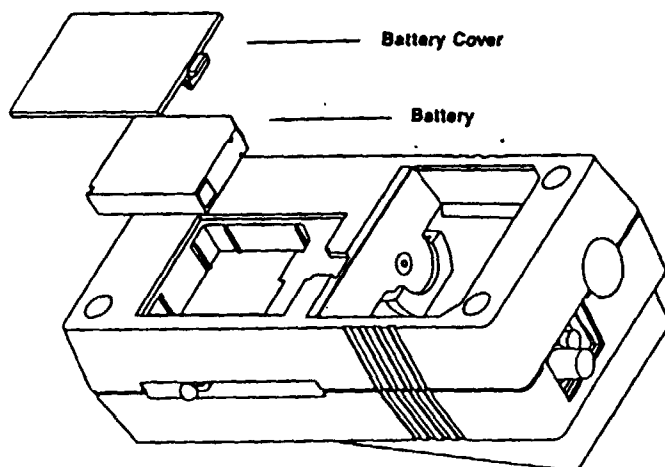
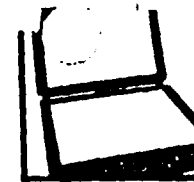


Figure 1. Battery Installation

WARNING

Battery may explode if recharged or disposed of in fire.



CARTRIDGE INSTALLATION

1. Press the **PLUNGER RELEASE BUTTONS**, Figure 2A, on the sides of the meter and slide the plunger all the way to the **PRIMING KNOB** end of the meter; see Figure 2B. The plunger must be completely recessed in order to slide the cartridge in.

Note

Visually check the cartridge to see if crystals are present in the solution before installing a new cartridge in the meter in the following manner: hold the cartridge up to the light with tip down to view the clear plastic areas of the cartridge and invert several times. Crystals, if present, will be seen easily and interfere with later operation. Dissolve crystals by immersing the cartridge in warm water and shake the cartridge periodically until all crystals redissolve.

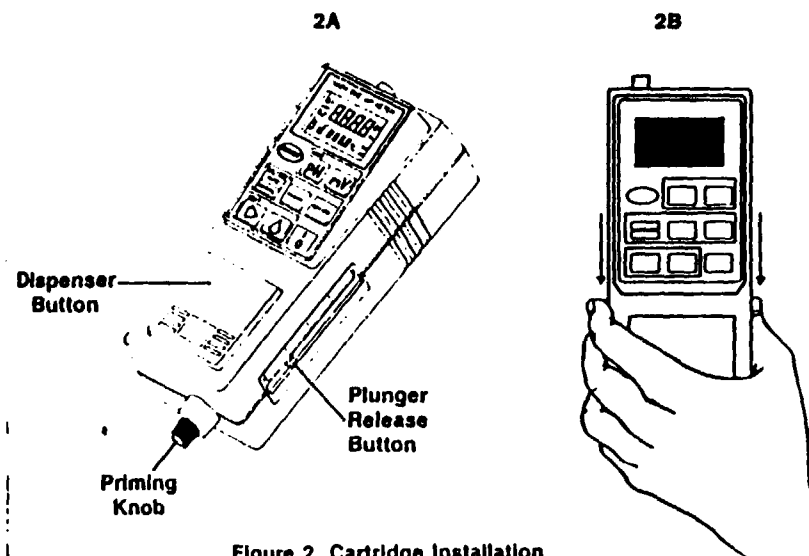


Figure 2. Cartridge Installation



2. Turn the meter upside down and slide the tip of the solution cartridge through the large opening in the meter base and then through the oval opening. See Figure 2C. Slide the flat end of the cartridge firmly into the semicircular slot in the meter; note the horizontal orientation of the tabs.

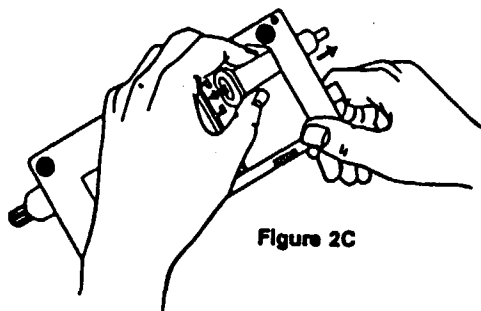


Figure 2C

3. Press the PLUNGER RELEASE buttons and slide the plunger toward the solution cartridge until it stops against the solution cartridge seal.

Figure 2D illustrates the Hach One Portable pH/mV meter assembled with the cartridge.

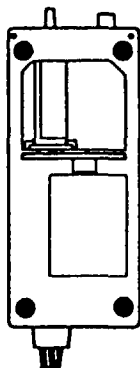
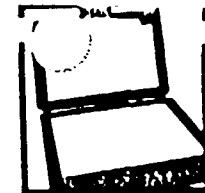
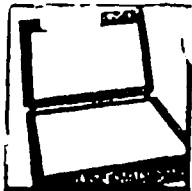


Figure 2D



ELECTRODE INSTALLATION

1. Twist and pull the cap from the solution cartridge tip and the plug from the end of the electrode tubing connector. Install the electrode tubing connector on the cartridge tip by pressing with a slight rotating motion. The cartridge tip cap can be stored on the electrode tubing connector plug.
2. Remove the cap and cotton wad from the pH electrode tip. Examine the glass bulb to be sure it is filled with solution. The electrode will not function properly if an air bubble is in the bulb area. Remove air by shaking down the electrode in the same manner as you would a clinical thermometer. Replace the cap when the electrode is not being used.
3. Hold the meter so the cartridge tip points upward. Rotate the PRIMING KNOB counterclockwise until electrode solution emerges from the electrode tip. Five complete turns are necessary to purge all the air bubbles from the electrode tubing. Failing to purge the system of air may result in erratic or inaccurate measurements.
4. Immerse the glass bulb in the electrode tip in a beaker of deionized water and dispense a small amount of electrode solution by turning the PRIMING KNOB counterclockwise. The electrode should be held off of the bottom in order to observe the dense electrode solution sinking from the electrode tip. (Throughout this manual the term, deionized, refers to distilled, demineralized or deionized water.)
5. Connect the electrode BNC connector to the BNC receptacle on the Hach One pH Meter. Connect the temperature probe plug to the temperature probe jack.
6. Calibrate the pH meter as described Part 2, pH Calibration. During calibration and operation, a small amount of electrode solution should be dispensed each time the electrode is placed in a new sample. Depress the DISPENSER BUTTON until it clicks. This delivers 6 μ L of electrode solution, a sufficient amount for most samples. Dispensing more electrode solution usually is unnecessary.



ELECTRODE STORAGE AND DISASSEMBLY

The Hach One Electrode can be stored dry in air without harm to the glass membrane. The glass will rehydrate quickly when immersed in water and an immediate response is obtained in concentrated solutions like calibration buffers.

Follow these steps to disassemble after use:

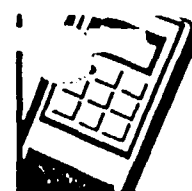
1. Remove the electrode from the sample and rinse with deionized water.
2. Cover the electrode tip with the cotton wad and black electrode cap. Lay the electrode down.
3. Disconnect the electrode tubing connector and insert the electrode tubing connector plug.
4. Tightly place the cartridge cap on the electrode solution cartridge.

Note

Wipe any spilled electrode solution with a damp cloth immediately. The electrode solution may damage metal and electrical parts.

5. Disconnect the BNC connector and the temperature probe.
6. Place the meter and the electrode into the case.

See Part 3, Maintenance for additional information on storage.



PART 2. OPERATION

INSTRUMENT DESCRIPTION

The Hach Model 43800 Portable Hach One™ pH Meter is a multipurpose microprocessor-controlled laboratory instrument with an integral Reference Solution Dispenser Pump.

It has been designed to measure pH, specific ion activity and millivolt potentials. The instrument will calculate, store, temperature compensate and display all parameters for pH measurements.

It has both automatic buffer recognition and manual calibration modes. The automatic buffer recognition mode uses pH 4.01, 7.00 and 10.00 Hach Powder Pillow Buffers. A two-buffer calibration may be used with any two of these buffers in any sequence. The manual mode may be used with any buffers, at least one pH unit apart, over the entire measurement range.

The Hach One pH Meter will provide direct digital readouts in pH units (-1.99 to 19.99) or millivolts (0 to ± 1999 mV). The four-digit display provides sensitive, accurate readings. If a temperature probe is attached, readings from -5 to 105°C may be obtained.

With the Hach One Combination pH Electrode and Temperature Sensor, the range is 0 to 14 pH units and the temperature range is 0 to 100°C.

Oxidation-reduction potential (ORP) and many ion selective electrodes may be used with calibration curves to correlate millivolt values with the constituent values.



DESCRIPTION OF OPERATING CONTROLS

Figure 3 illustrates the keys and indicators of the Hach One pH Meter. Functional descriptions of each are given in the accompanying table.

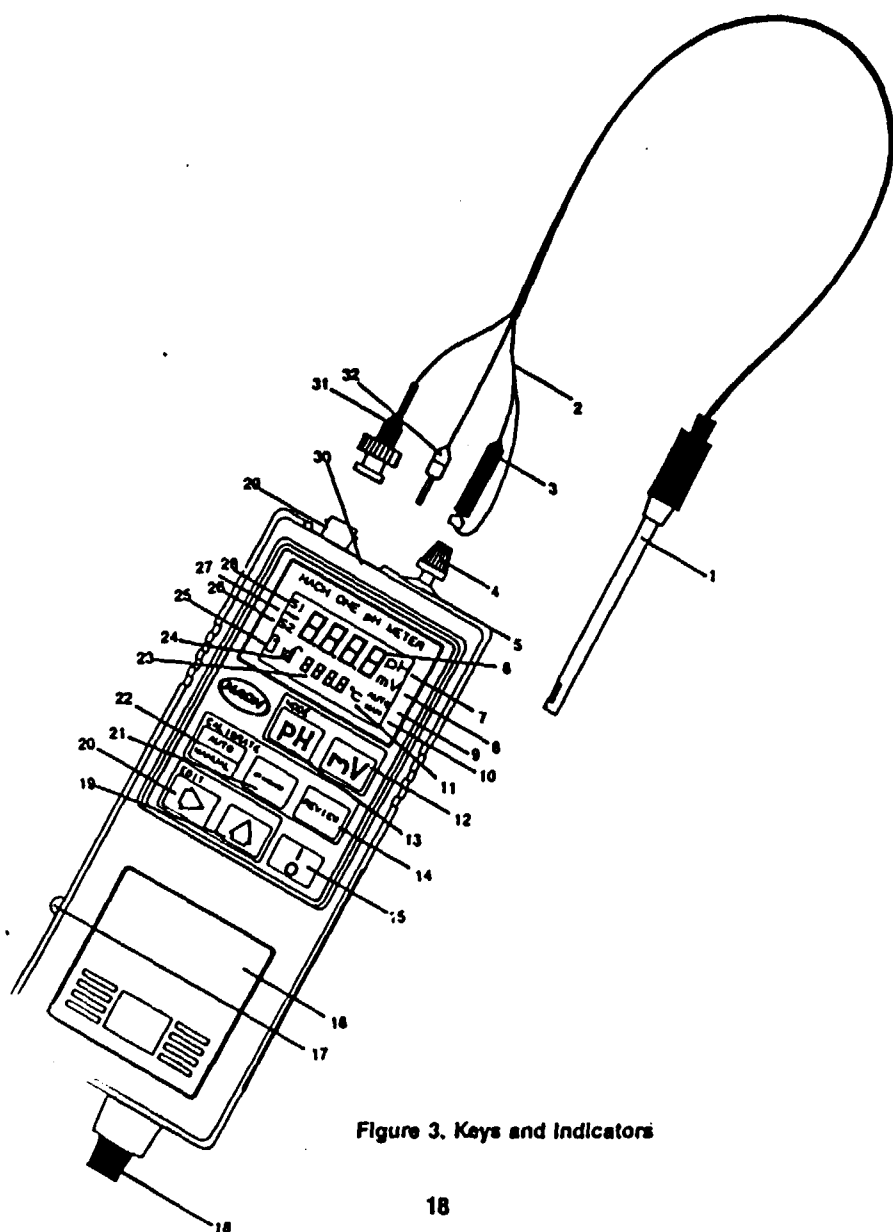
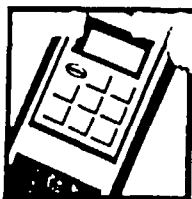


Figure 3. Keys and Indicators



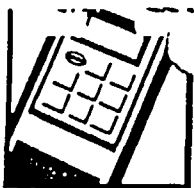
Item	Name	Description
1.	Electrode (Probe)	Hach One Combination Electrode
2.	Electrode Solution Tubing	Tubing for electrode solution
3.	Connector & Plug	Attaches the electrode solution tubing to the electrode solution cartridge
4.	Cap	Used to prevent loss or contamination of electrode solution during storage
5.	Solution Cartridge	Contains electrode solution
6.	Display	LCD display of pH or mV values with two display modes, normal and editing. In normal display mode, the digits light; while in the editing display mode one of the digits will flash.
7.	pH Indicator	If the pH key, Item 13, is activated, the pH indicator will light.
8.	mV Indicator	If the mV key, Item 12, is activated, the mV indicator will light.
9.	Auto Indicator	If the Auto/Manual key, Item 22, is activated in the pH mode, the Auto indicator will light. This shows that the meter is calibrating in the automatic buffer recognition mode.
10.	Man Indicator	If the Auto/Manual key, Item 22, is depressed again when in the pH mode, the Man indicator will light. This indicates the meter is in the manual calibration mode.
11.	°C	If lighted, it indicates the value shown in the temperature display, Item 23, has the units of degrees Celsius. If it is flashing, the temperature probe is not connected.



12. **mV Key** Millivolt mode key. When activated, the mV indicator will light and the display, Item 6, will read millivolts. The calibrate and edit keys as outlined on the keyboard will be inoperative. If a pH calibration is in progress, it will be canceled.
13. **pH Key** pH mode key. When activated, the pH indicator will light and the display, Item 6, will read pH units. If the pH key is depressed during a calibration, the calibration in progress will be lost. If the pH key is depressed at the completion of a calibration sequence, the appropriate values will be updated.
14. **Review Key** Calibration review key. Displays the offset and slope values used to determine the current calibration. The offset in millivolts will appear in the larger display with the mV indicator displayed. The slope in millivolts per pH unit will appear in the smaller display. Press again and return to the pH mode.
15. **Power Key** Turns on instrument power. Will need to be activated if a key has not been used within six minutes. If the key is depressed and held when the meter is turned on, all of the display symbols will appear.
16. **Dispenser Button** Used to dispense electrode solution from the cartridge.
17. **Plunger Release Buttons** Used to move dispenser plunger.
18. **Priming Knob** Used to prime electrode solution cartridge. Turn counterclockwise to dispense solution.



19. **Up Arrow Key** Each press and release of the Up Arrow key increments the flashing number when in the editing mode. The range for the left-most digit in the display is 0 to 1 to 0. The range for the left-most digit in the temperature display is 0 to 1 to - to 0. The range for all the other digits is 0 to 9 to 0. The internal software will not allow the user to enter an inappropriate value. An example is entering 110 in the temperature display. The 110 is out of the -5 to 105°C range and cannot be entered. To enter 104 the zero and the four must be entered first. The Right Arrow key is then advanced and the one entered. This procedure is unnecessary for the pH display.
20. **Right Arrow Key** Moves the flashing number to the next right digit. If the temperature probe is not connected, it will initiate editing of the temperature display. Increment this digit with the Up Arrow key or if it is a leading blank, a flashing zero, press the Right Arrow key to advance to the next digit.
21. **Standard Key** Initiates reading of a buffer used in a calibration sequence.
22. **Auto/Manual Key** Selects the calibration mode, either the automatic buffer recognition mode or manual buffer recognition mode, and starts the calibration sequence.
- Press once: Initiates the automatic buffer recognition calibration mode. The Auto indicator will light. The meter has been preprogrammed for using Hach Powder Pillow Buffers labeled pH 4.01, 7.00 or 10.00 in any order to calibrate the instrument.
- Press again: Initiates the manual buffer recognition mode. The Man indicator will light. The editing mode will be initiated with the left-most digit flashing. If the temperature probe is not connected, the temperature may be edited as well.



23. Temperature Display

Continuously displays the temperature in 0.2 inch digits. When the temperature probe is not connected, the meter uses the last manually entered temperature or 25°C. The meter uses the displayed value to compensate the pH reading automatically for temperature. The letters, HI, will appear if the temperature is greater than 105°C. LO will appear if the temperature is less than -5°C.

24. Probe Indicator

Flashes until the reading is stable. In low ionic-strength samples it may take up to three minutes. If the instability is due to the probe or sample, it will continue to flash. Corrective action is needed; see Troubleshooting, Part 4. If the indicator is lighted but not flashing, the last calibration offset deviation was in the range of 60 to 120 mV and/or the slope deviated from -59.2 mV/pH unit by 15 to 30%. It will remain lighted until a new calibration is completed.

25. Battery Indicator

The battery indicator will light up when the voltage becomes low. When the voltage becomes too weak to operate the meter circuits, the instrument will turn itself off while maintaining calibration data in memory.

26. S2 Indicator

The S2 indicator will flash during a calibration when the second standard of a calibration is expected. The S2 indicator will light when the information on the display refers to the second standard.

27. Minus Sign

The minus sign will light when the meter reads a negative value.

28. S1 Indicator

The S1 indicator will flash during a calibration when the first standard is expected. The information on the display refers to the first standard.



- | | |
|---------------------------------------|--|
| 29. BNC Receptacle | Attachment for BNC connector. |
| 30. Temperature Probe Jack (recessed) | Attachment for temperature probe. |
| 31. BNC Connector | Attaches the electrode to the meter. |
| 32. Temperature Probe Plug | Attaches the temperature probe to the meter. |

ELECTRODE DESCRIPTION

Hach One Electrodes feature a vastly improved design providing fast response and measurement accuracy; see Figure 4. Error due to variations in reference junction potentials caused by junction clogging has been virtually eliminated.

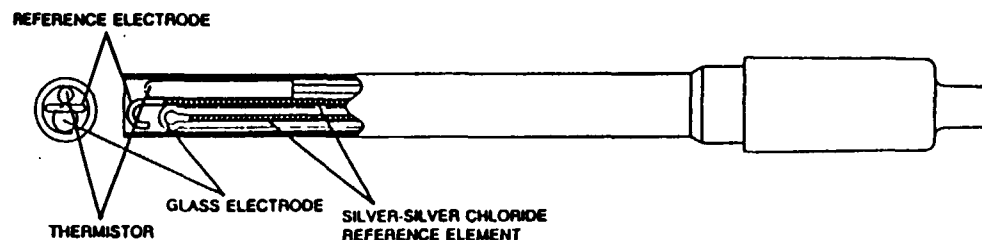
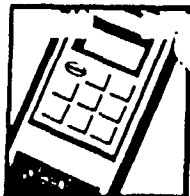


Figure 4. Hach One Combination pH Electrode with Temperature Sensor



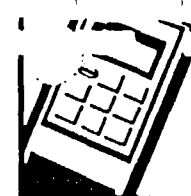
Hach One pH Electrodes have silver-silver chloride reference elements. Electrode solution for the reference half-cell is metered through an open reference junction by using a special dispenser. One touch on the dispenser control button dispenses just the right amount of electrode solution through the reference junction. Electrode solution is dispensed through Teflon tubing which also encloses the silver-silver chloride reference element. Model 44250, the Hach One Reference Half-Cell Electrode, is available for use with two-electrode systems. Electrode solution for Hach One Electrodes is contained in disposable plastic cartridges to ensure fresh, contaminant-free solution.

The Hach One Electrode will provide greater accuracy and reliability for pH measurement than any other pH electrode available. Unique design and construction of Hach One Electrodes make them ideal for routine and special applications of pH measurement. Convenient for field or small-sample testing, the slim body of the Hach One (10.5 mm diameter) will fit into a 13-mm test tube for measurement of samples as small as 1.5 mL.

The Hach One uses a low-resistance glass so that it can be used down to 0°C. Although low-resistance glass hydrates easily, it has less durability at high temperatures. In addition, a moderate sodium error occurs at pH levels greater than 12 when low-resistance glass is used.

PRINCIPAL OF ELECTRODE OPERATION

Fresh electrode solution is dispensed from a cartridge through a free-flowing liquid junction as needed. Diluted electrode solution and contaminants are removed continuously from the vicinity of the junction. Build-up of junction potential, common with electrodes with porous plugs, does not occur with the free-flowing junction. Accordingly, samples of varying ionic strengths are measured accurately. The electrode solution is metered by a dispenser, controlled by a DISPENSER BUTTON, PRIMING KNOB and PLUNGER RELEASE BUTTONS. One push on the DISPENSER BUTTON triggers delivery of 6 μ L of electrode solution from the cartridge. Hach One Electrodes provide quick, stable readings in a temperature range of 0 to 100°C (32 to 212°F). Intermittent use only is recommended above 45°C (113°F).



Applications for the Hach One Portable pH Meter include:

- Monitoring the pH of low ionic strength liquids such as ultrapure water and acid rain samples.
- Ecology studies of natural waters (lakes, rivers and streams).
- Water and wastewater treatment to monitor influent and effluent quality.
- Agricultural applications (soil, fertilizer, food and feed).
- Chemical and biological research.
- Industrial processes in the manufacture of foods, beverages, pharmaceuticals, dyes, photographic film and reagent grade chemicals.
- Medical laboratory studies of body fluids such as blood and urine.

OPERATION MODES

The three fundamental parameters measured by the Hach One Portable pH Meter are temperature, pH and millivolts.

TEMPERATURE MEASUREMENT

Temperature is measured only when the temperature probe is connected to the meter. If the temperature probe is not connected, the meter will display the last value entered manually or the default value of 25°C and the °C will flash. Temperature values may be changed by using the Up Arrow and Right Arrow keys when the temperature probe is disconnected.

Preliminary adjustments are not needed for taking temperature measurements. Once the probe is connected, immerse the probe tip in the test sample. Allow 30 seconds for the probe to stabilize and take the reading.

LABORATORY THERMOMETER

The Hach One pH Meter may be utilized as a laboratory thermometer with the purchase of a stainless steel temperature probe (Cat. No. 43976-00); see Figure 5. Simply plug in, attach the BNC shorting cap, and read the value in the temperature display. The BNC shorting cap stabilizes the erratic display.

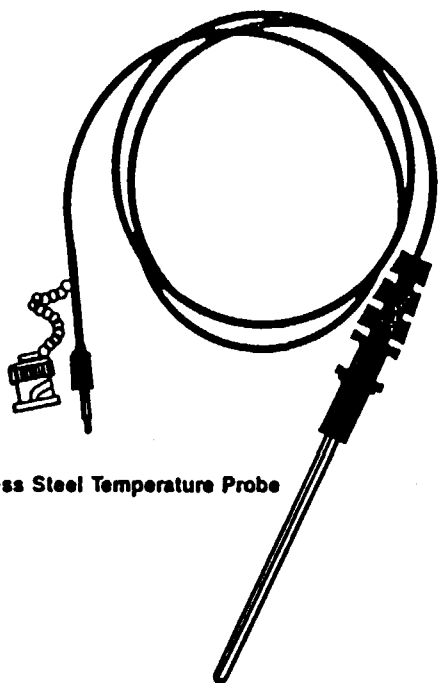


Figure 5. Stainless Steel Temperature Probe

With the stainless steel temperature probe, other pH probes may be used with the Hach One pH Meter and have automatic temperature compensation in the pH mode.

In the millivolt mode, oxidation-reduction potential and ion selective electrodes may be used. The temperature probe will provide an accurate measurement of sample temperature.

pH MEASUREMENT

pH is used to describe the hydrogen ion activity in a solution. The influence of the hydrogen ion activity in a solution on a pH electrode may be described by two parameters, offset and slope. A more complete explanation of pH is given in Appendix A, Theory of pH Measurement.

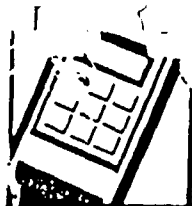
The offset is defined as the difference between the observed potential and the expected potential at pH 7.00. The default offset programmed into the Hach One Portable pH Meter is 0.00 mV.



The slope is defined as the change in potential per pH unit. The default slope programmed into the Hach One Portable pH Meter is -59.2 millivolts per pH unit.

These default values will change each time a calibration is performed. A one-buffer calibration will change only the offset, while a two-buffer calibration will change both the offset and slope.

The values used for offset and slope are as close as the touch of a button. In the pH mode the Review key, when pressed, will display the current offset in terms of millivolts in the display and the current slope in millivolts per pH unit in the temperature display. This data is invaluable to verify the accuracy of calibration and sample measurement over time. If the offset and slope exceed the normal expected calibration variations the probe indicator will light. Larger variations will cause error messages to occur. These indicators and error messages are explained in more detail in the Troubleshooting section.



pH CALIBRATION

There are several ways to calibrate the pH meter. For the most accurate measurements, do a two-buffer calibration at least daily. A one-buffer calibration is less accurate but useful in routine applications. The factory or default calibration usually is the least accurate but the quickest to use.

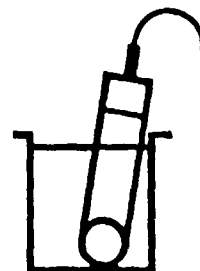
The Hach One pH Meter has been designed for these calibrations to be carried out in either an automatic buffer recognition (automatic) mode or a manual mode. In the following pH Calibration Procedure section each of these calibrations is described in detail. These calibrations include two-buffer calibration using automatic mode, two buffer calibration using manual mode, two-buffer calibration using automatic mode for one buffer and manual mode for the second buffer, one-buffer calibration using automatic mode, one-buffer calibration using manual mode and factory calibration.

In each procedure, bracketed steps, [], tell what action needs to be taken if the temperature probe is malfunctioning or not plugged in. The temperature may be entered using the Edit keys. In some situations it may not be necessary to enter a temperature if the currently displayed temperature is correct. Every three degrees Celsius difference between the displayed temperature and the actual solution temperature will cause a one per cent deviation per pH unit difference from pH 7. This means at pH 3 the effect of temperature on the pH measurement, when there is a difference in temperature from the display to the actual temperature, is more significant than at pH 6.

In all pH measurements, the results are only as good as the buffers used in the calibration procedure. Hach pH Powder Pillow Buffers are simple to prepare and accurate. Powder pillow packaging ensures the proper proportion of fresh, contaminant-free reagent. Prepare buffer solutions by:

1. Open the powder pillow with the clippers provided with the meter.
2. Dissolve the contents of one powder pillow in 50 mL of deionized water and mix. See Part 6 for product ordering information and premixed solutions.

Accurate pH measurements are easy with the Hach One when the air bubbles in the electrode are removed. Not removing all of the air bubbles is the cause of inaccurate readings. Air bubbles are removed by dispensing more buffer solution. Press the Buffering Button. More air bubbles can be removed by turning the Knob counterclockwise.



If the probe indicator is lighted but not flashing during a calibration, it indicates a warning about the last calibration and not the current calibration. The lighted indicator won't turn off until the current calibration is completed.

PROMPTING

The Hach One Portable pH Meter uses prompting indicators to direct the operator through calibration. When one of the program modes (automatic or manual calibration) has been selected, the instrument will prompt the operator as to the calibration requirements by flashing key indicators (S1 or S2) in the automatic calibration mode plus initiate editing of the display in the manual calibration mode; see Figure 6.

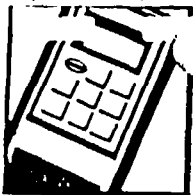


Figure 6. Prompting Indicators

pH CALIBRATION PROCEDURES

TWO-BUFFER CALIBRATION USING AUTOMATIC MODE

1. Press: The display will light.
2. Press:



3. Press: **AUTO** The Auto indicator will light; see Figure 7. The S1 and pH indicators will flash. Zeros will appear in the display.

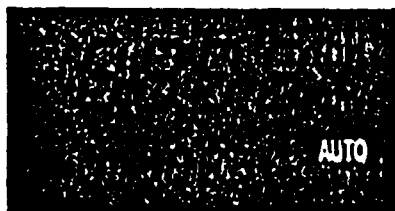


Figure 7. Auto Indicator

[If the temperature probe is not connected, determine temperature of the buffer. Press the Right Arrow key once and then enter the temperature using the Right Arrow and Up Arrow keys. The Right Arrow moves the flashing number to the next right digit, while the Up Arrow increments the flashing number. See page 21 for a detailed description of the Up Arrow key. The °C will continue to flash as long as a temperature probe is not connected.]

4. Place the electrode into a pH 4.01 Hach Powder Pillow Buffer and press the Dispenser Button. The temperature display will show the actual solution temperature throughout the entire sequence of steps if the temperature probe is connected.
5. Press: **ENTER** and wait until the pH indicator stops flashing. The S2 indicator now will begin flashing. The actual pH value will appear in the display. If the solution temperature deviates from 25°C, the display will show the actual pH and not 4.01.

Fluctuating readings: If the screen displays a fluctuating reading or gives an E 1 error code, air bubbles in the electrode solution tubing are the cause. Air bubbles are removed by dispensing more electrode solution with the Dispensing Button. More air bubbles can be removed by turning the Priming Knob counterclockwise.



6. Rinse the electrode with deionized water.

[If the temperature probe is not connected, determine the temperature of the buffer. Press the Right Arrow key once and then enter the temperature using the Right Arrow and Up Arrow keys. The °C will continue to flash as long as a temperature probe is not connected.]

Place the electrode into a pH 7.00 Hach Powder Pillow Buffer and press the Dispenser Button.

7. Press: **ENTER** S2 will stop flashing. Wait until the pH indicator stops flashing. The actual pH value will appear in the display. If the solution temperature deviates from 25°C, the display will show the actual pH and not 7.00.

Fluctuating readings: If the screen displays a fluctuating reading or gives an E 1 error code, air bubbles in the electrode solution tubing are the cause. Air bubbles are removed by dispensing more electrode solution with the Dispensing Button. More air bubbles can be removed by turning the Priming Knob counterclockwise.

8. Press: **pH** Rinse the electrode with deionized water, place into sample and press the Dispenser Button. The meter now measures pH.
9. If desired, press: **REVIEW** Note the offset and slope used in determining pH. Press the Review key again to return to measuring pH.

In the automatic buffer recognition mode, Hach Powder Pillow Buffers, pH 4.01, 7.00 and 10.00 may be used in any sequence.



TWO-BUFFER CALIBRATION USING MANUAL MODE

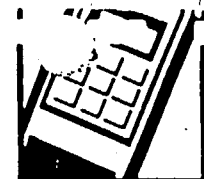
1. Press: **ON/OFF** The display will light.
2. Press: **pH**
3. Press: **AUTO** **MANUAL** Two times. The Man indicator will light; see Figure 8. The S1 indicator, the left-most digit and the pH indicator will flash.



Figure 8. Man Indicator

4. Place the electrode into a standard buffer and press the Dispenser Button.
5. Determine the pH of the standard buffer at its current temperature from a table of values. The current temperature is shown in the temperature display if the temperature probe is connected. Appendix C has a table of Hach liquid and powder buffers showing temperature versus pH.
6. Use the Right Arrow and Up Arrow (**→** **↑** Edit keys) to enter the determined pH of the standard buffer in the display. The Right Arrow moves the flashing number to the next right digit, while the Up Arrow increments the flashing number. See page 21 for a more detailed description of the Up Arrow key.

[If the temperature probe is not connected, determine the temperature of the buffer and enter it in the temperature display using the Right Arrow and Up Arrow. Use the Right Arrow to move number from the display to the temperature display. The °C will continue to flash as long as a temperature probe is not connected.]



7. Press: **ENTER** and wait until the pH indicator stops flashing momentarily, about four seconds. The S2 indicator and the left-most digit now will begin flashing. Zeros or a previous calibration value will appear in the display to be edited, if necessary, for the second standard in Step 9.

Fluctuating readings: If the screen displays a fluctuating reading or gives an E 1 error code, air bubbles in the electrode solution tubing are the cause. Air bubbles are removed by dispensing more electrode solution with the Dispensing Button. More air bubbles can be removed by turning the Priming Knob counterclockwise.

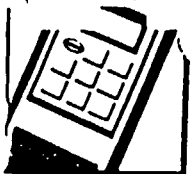
8. Rinse the electrode with deionized water. Place into a second standard buffer and press the Dispenser Button.

[If the temperature probe is not connected, determine buffer temperature.]

Determine the pH of the standard buffer at its current temperature from a table of values. Appendix C has a table of Hach liquid and powder buffers showing temperature vs. pH.

9. Use the Right Arrow and Up Arrow (**→** **↑** Edit keys) to enter the determined pH value in the display.

[If the temperature probe is not connected, enter buffer temperature using the Right Arrow and Up Arrow keys in the temperature display. Use the Right Arrow to move the flashing number from the display to the temperature display. The °C will continue to flash as long as a temperature probe is not connected.]



10. Press: **MANUAL** S2 will stop flashing. Wait until the pH indicator stops flashing.

Fluctuating readings: If the screen displays a fluctuating reading or gives an E 1 error code, air bubbles in the electrode solution tubing are the cause. Air bubbles are removed by dispensing more electrode solution with the Dispensing Button. More air bubbles can be removed by turning the Priming Knob counterclockwise.

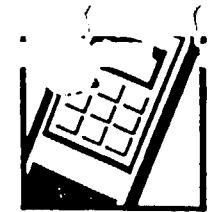
11. Press: **pH** Rinse the electrode with deionized water, place into sample and press the Dispenser Button. The meter now measures pH.
12. If desired, press: **REVIEW** Note the offset and slope used in determining pH. Press the Review key again to return to measuring pH.

TWO-BUFFER CALIBRATION USING AUTOMATIC MODE FOR ONE BUFFER AND MANUAL MODE FOR THE OTHER BUFFER

1. Press: **0** The display will light.
2. Press: **pH**
3. Press: **AUTO** The Auto indicator will light. The S1 and pH indicators will begin flashing. The display will show all zeros.
4. Place the electrode into a pH 4.01 Hach Powder Pillow Buffer and press the Dispenser Button. The temperature display will show the actual solution temperature throughout the entire sequence of steps if the temperature probe is connected.

[If the temperature probe is not connected, determine temperature of the buffer, press the Right Arrow key once and then enter the buffer temperature using the Right Arrow and Up Arrow in the temperature display. The Right Arrow moves the flashing number to the next right digit, while the Up Arrow increments the flashing number. The °C will continue to flash as long as a temperature probe is not connected.]

In the automatic buffer recognition mode, pH 7.00 Hach Powder Pillow Buffers also may be used.



5. Press: **MANUAL** S1 will stop flashing. Wait until the pH indicator stops flashing. The S2 indicator will begin flashing. The actual pH value will appear in the display. If the solution temperature deviates from 25°C, the display will show the actual pH and not 4.01.

Fluctuating readings: If the screen displays a fluctuating reading or gives an E 1 error code, air bubbles in the electrode solution tubing are the cause. Air bubbles are removed by dispensing more electrode solution with the Dispensing Button. More air bubbles can be removed by turning the Priming Knob counterclockwise.

6. Rinse the electrode with deionized water. Place into the second standard buffer and press the Dispenser Button.
7. Press: **AUTO** The Man indicator will light.

The S2, the left-most digit and the pH indicator will begin flashing. Determine the pH of the standard buffer at its current temperature from a table of values. Appendix C has a table of Hach liquid and powder buffers showing temperature versus pH.

8. Use the Right Arrow and Up Arrow (**→** **↑** Edit keys) to enter the determined pH value in the display. The Right Arrow moves the flashing number to the next right digit, while the Up Arrow increments the flashing number.

[If the temperature probe is not connected, determine the buffer temperature and enter it in the temperature display using the Right Arrow and Up Arrow. Use the Right Arrow to move the flashing number from the display to the temperature display. The °C will continue to flash as long as a temperature probe is not connected.]

9. Press: **MANUAL** S2 will stop flashing. Wait until the pH indicator stops flashing. The value entered in Step 8 will appear in the display.

Fluctuating readings: If the screen displays a fluctuating reading or gives an E 1 error code, air bubbles in the electrode solution tubing are the cause. Air bubbles are removed by dispensing more electrode solution with the Dispensing Button. More air bubbles can be removed by turning the Priming Knob counterclockwise.



10. Press: **pH** Rinse the electrode with deionized water, place into sample and press the Dispenser Button. The meter now measures pH.
11. If desired, press: **REVIEW** Note the offset and slope used in determining pH. Press the Review key again to return to measuring pH.

Calibration may also be done using the manual mode first and the automatic mode second.

ONE-BUFFER CALIBRATION USING AUTOMATIC MODE

1. Press: **0** The display will light.
2. Press: **pH**
3. Press: **AUTO** The Auto indicator will light.
4. Place the electrode into a pH 7.00 Hach Powder Pillow Buffer and press the Dispenser Button. S1 and pH indicators will be flashing. Zeros will appear in the display. The temperature display will show the actual solution temperature throughout the entire sequence of steps if the temperature probe is connected.

[If the temperature probe is not connected, determine temperature of the buffer, press the Right Arrow key once and then enter the temperature using the Right Arrow and Up Arrow in the temperature display. The Right Arrow moves the flashing number to the next right digit, while the Up Arrow increments the flashing number. See page 21 for a detailed description of the Up Arrow key. The °C will continue to flash as long as a temperature probe is not connected.]

In the automatic buffer recognition mode, Hach Powder Pillow Buffers, pH 4.01 or 10.00 also may be used.

5. Press: **MANUAL** S1 will stop flashing. Wait until the pH indicator stops flashing. S2 will begin flashing. The pH value will appear in the display. If the solution temperature is from 25°C, the display will show the actual



Fluctuating readings: If the screen displays a fluctuating reading or gives an E 1 error code, air bubbles in the electrode solution tubing are the cause. Air bubbles are removed by dispensing more electrode solution with the Dispensing Button. More air bubbles can be removed by turning the Priming Knob counterclockwise.

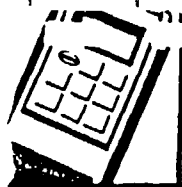
6. Press: **pH** Rinse the electrode with deionized water, place into sample and press the Dispenser Button. The meter now measures pH.
7. If desired, press: **REVIEW** Note the offset and slope used in determining pH. Press the Review key again to return to measuring pH.

ONE-BUFFER CALIBRATION USING MANUAL MODE

1. Press: **0** The display will light.
2. Press: **pH**
3. Press: **AUTO** two times. The Man indicator will light. The S1 and pH indicators will begin to flash.
4. Place the electrode into a standard buffer and press the Dispenser Button.

The left-most digit and the pH indicator will begin flashing. Zeroes or a previous calibration value will appear in the display to be edited, if necessary, in Step 5. Determine the pH of the standard buffer at its current temperature from a table of values. The current temperature is shown in the temperature display. Appendix C has a table of Hach liquid and powder buffers showing temperature vs. pH.

5. Use the Right Arrow and Up Arrow (**→** **↑** Edit keys) to enter the determined value in the display. The Right Arrow moves the flashing number to the next right digit, while the Up Arrow increments the flashing number. See page 21 for a detailed description of the Up Arrow key.



[If the temperature probe is not connected, determine temperature of the buffer and enter it in the temperature display using the Right Arrow and Up Arrow. Use the Right Arrow to move the flashing number from the display to the temperature display. The °C will continue to flash as long as a temperature probe is not connected.]

6. Press: **SI** SI will stop flashing. Wait until the pH indicator stops flashing momentarily, about four seconds. The value entered in Step 5 will appear. The S2 indicator and the left most digit now will begin to flash. Zeros or a previous calibration value will appear in the display and may be disregarded.

Fluctuating readings: If the screen displays a fluctuating reading or gives an E 1 error code, air bubbles in the electrode solution tubing are the cause. Air bubbles are removed by dispensing more electrode solution with the Dispensing Button. More air bubbles can be removed by turning the Priming Knob counterclockwise.

7. Press: **pH** Rinse the electrode with deionized water, place into sample and press Dispenser Button. The meter now measures pH.
8. If desired, press: **REVIEW** Note the offset and slope used in determining pH. Press the Review key again to return to measuring pH.

FACTORY CALIBRATION

To return the meter to the factory set offset of 0.00 mV and slope of -59.2 mV/pH unit, turn the meter on and remove the battery from the instrument for five seconds or longer. Use the Review key to verify these are the new default values.

STABILITY OF READINGS

The Hach One Meter has been designed to provide pH measurement stability information. During calibration the pH indicator flashes when the readings are unstable; see Figure 9A. During sample measurements in the pH mode, the probe indicator will flash when the measurements are unstable; see Figure 9B.

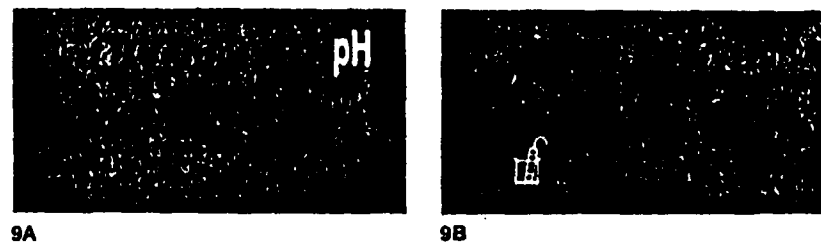
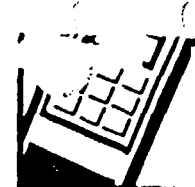


Figure 9. Stability Indicators

SAMPLE PROCEDURE

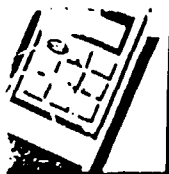
Calibration and measurement are two fundamental steps in every pH measurement. Calibration, also called standardization, compensates for changes in the meter or electrode(s). Measurement determines the sample pH.

Calibration

1. Calibrate the meter by one of the pH calibration procedures described in the above pH Calibration section. The two-buffer calibration using the automatic buffer recognition mode with the temperature probe is recommended, see Note A for buffer preparation. Press the pH key when the calibration is completed.

Measurement

2. Rinse the electrode well with deionized water.
3. Place the electrode(s) in the sample to be tested. Depress the DISPENSER BUTTON once to dispense electrolyte. Stir the sample; see Note C. Read the pH value from the meter; the section on Optimizing Electrode Performance has additional helpful information. If CO₂ absorption is a concern, see Note B.



Fluctuating readings: If the screen displays a fluctuating reading or gives an E 1 error code, air bubbles in the electrode solution tubing are the cause. Air bubbles are removed by dispensing more electrode solution with the Dispensing Button. More air bubbles can be removed by turning the Priming Knob counterclockwise.

4. Rinse the electrode with deionized water after sample measurement.

Notes

- A. pH buffer solution preparation is easy with Hach pH Powder Pillow Buffers. Powder pillow packaging ensures the proper proportion of fresh, contaminant-free reagent. Prepare buffer solutions by adding the contents of one powder pillow to 50 mL of deionized water and mix. Premixed pH buffer solutions also are available. See Part 5 for product information.
- B. When measuring water with a low buffer capacity (such as boiler condensate or high purity natural water), it may be necessary to cover the solution during measurement to prevent change in the carbon dioxide concentration of the sample.
- C. Stirring the sample with the Hach One during measurement is recommended. Slow to moderate stirring will speed the response and will not shift the potential—as can occur with conventional porous junction electrodes. For field measurements the sample may be stirred with the electrode. For lab measurements a magnetic stirrer and stir bar work best.
- D. Do not immerse the electrode past the blue body of the probe in a solution.

Reagents and Apparatus—See Part 5, Reagents and Apparatus.



OPTIMIZING pH ELECTRODE PERFORMANCE

The greatest source of pH measurement error is a clogged reference junction. A clogged reference junction causes variation or irregularities in the liquid junction potential. The Hach One is designed so that the liquid junction potential is kept to a constant and minimal value.

Response Time

Normal response time in buffered solutions is only a few seconds. The response time will be slower, perhaps up to three minutes, in weakly buffered solutions from 10^{-3} M buffer to pure water. Conventional electrodes with porous junctions may require as much as 40 minutes in similar low-ionic strength solutions. Response time slows as the ionic strength and temperature decrease. If the response time becomes slower than usual, clean and soak the glass membrane in deionized water as described in Part 3, Maintenance-Normal Electrode Cleaning.

Storage

The Hach One can be stored dry in air without harm to the glass membrane. The glass will rehydrate quickly when immersed in water, and an immediate response is obtained in concentrated solutions like calibration buffers. For measurements in low ionic-strength samples, the electrode should be conditioned by immersion in deionized water.

Technique

It is better to stir the sample gently than to measure a still sample. Stirring the sample speeds the Hach One response dramatically in low ionic-strength samples. Conventional electrodes with ceramic junctions can give variable and shifted potentials upon stirring.

With the Hach One Electrode, press the Dispenser Button for more solution if the readings become erratic.



Temperature Factors

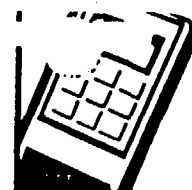
To optimize electrode performance, the electrode, buffers and test samples should be equilibrated at the same temperature prior to measurements. When transferring your electrode from one solution to another, rinse the tip thoroughly with the solution to be measured next or with deionized water.

Electrode solution cartridges that have been exposed to cold temperatures should be examined visually to be sure crystals, which could enter and obstruct the electrode solution tubing, have not formed inside the cartridge. If crystals are present, warm the cartridge, shaking it several times, until all crystals are redissolved.

The electrode is intended for continuous use in samples with temperatures ranging between 0 and 45°C (32 to 113°F). Prolonged use at higher temperatures will shorten its useful life, but intermittent use up to 100°C has no noticeable effect. At temperatures near 0°C, the measurement time for the electrode will increase.

The electrode solution cartridge contains 2.2 N KCl saturated with AgCl in 40% glycerin to enable the electrode to withstand freezing conditions.

If the temperature probe is malfunctioning or not plugged in, the temperature may be entered using the Edit keys. In some situations it may not be necessary to enter a temperature if the currently displayed temperature is correct. Temperature influences two different factors in every pH measurement. One factor is the temperature of the silver-silver chloride reference elements and glass bulb. The Hach One pH Meter has been designed to compensate automatically for the electrical changes in the reference elements and glass bulb due to temperature. Because of this design, every three degrees Celsius difference between the displayed temperature and the actual solution temperature will cause a one percent deviation per pH unit difference from pH 7. This means at pH 3 the effect of temperature on the pH measurement, when there is a difference in temperature from the display to the actual temperature, is more significant than at pH 6. The second factor is the solution temperature. Though a solution is labeled a pH 4.01 buffer, the actual pH is 4.01 only at 25°C. At other temperatures the pH will vary slightly depending on the characteristics of the chemicals used in preparing the buffer. In the automatic buffer recognition mode, the Hach One pH Meter will give the actual pH value. In the manual calibration mode, the user must be consulted for the pH of the buffer at the temperature of use.



Drift

In weakly buffered alkaline solutions, absorption of carbon dioxide from the atmosphere is a major cause of downward drift of pH readings. Loss of volatile acids or bases may cause drifting as well. Drifting is minimized by covering the sample during measurement.

Sodium Error

Acid error is negligible and negative sodium error, usually present in alkaline solutions, is low, even at pH values as high as 12. To determine the sodium error in pH units, measure the apparent pH and sodium concentration of the test solution and determine the error from the Sodium Ion Error Graph in Figure 10. Do this by locating the point (on the appropriate pH horizontal grid line) representing the sodium concentration based on the extrapolation between the 229, 2,290 and 22,900-mg/L Na plots. The vertical grid line at that point will indicate the negative sodium error (in pH units) that should be added to the apparent pH meter reading.

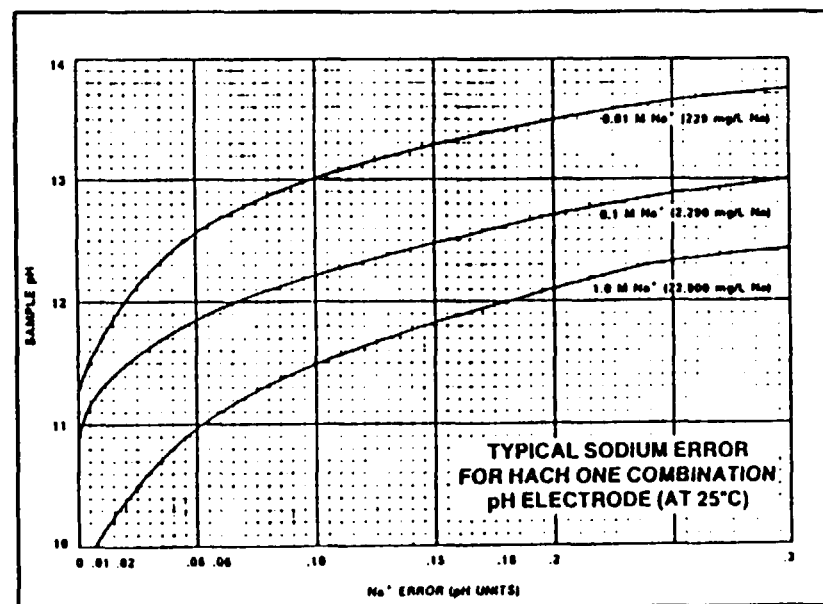
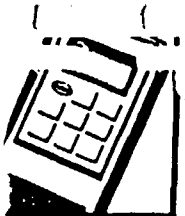


Figure 10. Sodium Ion Error Graph



MILLIVOLT MEASUREMENT

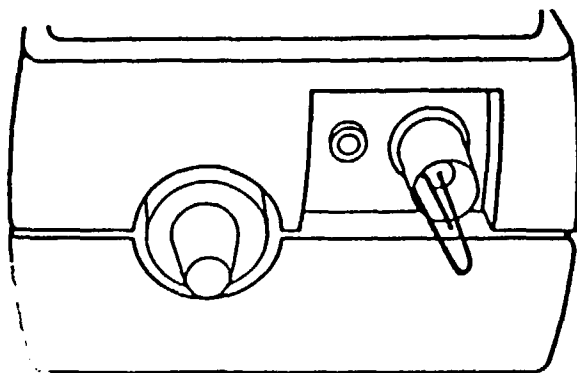
The Hach One Portable pH Meter may be used to read millivolts at any time by pressing the mV key. The mV indicator will light. With the proper probe, values from -1999 mV to 1999 mV may be read in this mode. If the reading is outside of this range the error message, E 8, will appear in the display.

For readings in the range of -999.9 to 999.9 mV, the meter will display tenths of millivolts. For readings outside of this range the meter will display readings to the nearest millivolt.

MILLIVOLT ZEROING

The meter may be zeroed for millivolt measurements by following this sequence:

1. Turn off the meter.
2. Insert the straightened end of the shortest bend of a No. 1, steel paper clip into the inner hole of the BNC receptacle; see Figure 11. Push the remainder of the paper clip so that it will slip into the inner sleeve of the receptacle. This will electrically short the BNC connector.



Actual Size

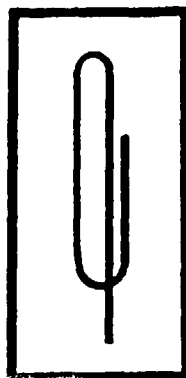
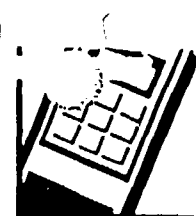


Figure 11. Zeroing the Hach One Meter



3. Press and hold: **mV**

Press and release: **!**

Release: **mV**

The mV indicator will light, and after about 10 seconds the meter will read 0.0 mV \pm 2 mV.

4. If there is a meter malfunction that will cause the reading to be less than -50 millivolts or greater than 50 millivolts, the error message, E 6, will appear. Additional troubleshooting information appears in Part 4.

If the above procedure is used routinely, a BNC shorting cap (Cat. No. 19024-00) is recommended to prevent damage to the gold contact of the BNC connector. Hach recommends that zeroing be done only when deemed necessary by the user and/or when replacing the battery. The instrument has been designed to maintain zero.

Because of the millivolt range of -1999 to +1999 mV, the Hach One Portable pH Meter can be used with ORP (oxidation-reduction potential) probes and many ion selective electrodes.



PART 3. MAINTENANCE

BATTERY REPLACEMENT

A low battery is signaled by the lighted battery indicator on the LCD display. When the voltage becomes too weak to operate the meter circuits, the instrument will turn itself off after two seconds while maintaining calibration data in memory. Replace the battery; see Part 1, Battery Installation.



CARTRIDGE REPLACEMENT

To replace the electrode solution cartridge, press the PLUNGER RELEASE BUTTONS on the sides of the dispenser and slide the plunger all the way to PRIMING KNOB end of the meter. Remove the cartridge from the meter.

ELECTRODE STORAGE

The electrode may be allowed to air-dry during storage with no damage and need not be kept wet or immersed during storage. A dry electrode responds quickly to strong solutions, like buffers, within 15 minutes after being placed in service. For fastest response in dilute, low ionic-strength samples, the glass membrane can be stored in deionized water. Storage in deionized water is acceptable because the free-diffusion junction of the Hach One cannot be clogged by precipitated AgCl. Note: Storing any glass membrane in water causes gradual deterioration as ions are leached from the glass.

If the electrode is to be stored for an extended period of time it should be prepared as follows: Disconnect the electrode solution tubing from the solution cartridge. Using a syringe, inject approximately 20 mL of deionized water through the electrode solution tubing to flush out the electrode solution. Use a dry syringe to force air through the electrode solution tubing to dry it. Install the cap with the cotton wad on the end of the electrode. Do not add any solution to the cotton wad. Replace the plug in the end of the electrode solution tubing. Follow instructions in Part 1 to place the electrode in service again.



NORMAL ELECTRODE CLEANING

WARNING

The hydrochloric acid and sodium hydroxide used in this procedure may be hazardous if inappropriately handled or accidentally misused. Please read all warnings on the reagent labels.

When the electrode response becomes sluggish or the electrode is fouled, it should be cleaned. Normal cleaning procedures follow: immerse the electrode tip in 0.1N Hydrochloric Acid followed by immersion in 0.1N Sodium Hydroxide and again in 0.1N Hydrochloric Acid, each for a two-minute period. Rinse with deionized water; soak in deionized water for at least 15 minutes.

Oils and fats can be removed by immersing the electrode tip in a detergent solution such as Alconox. Use a soft brush or ultrasonic bath if necessary. Avoid scratching the glass bulb!

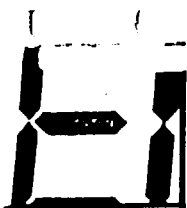
Organic films may be removed from the glass bulb by using an appropriate solvent, such as methanol or acetone.

If the glass bulb becomes contaminated, it may be reconditioned by following the above cleaning procedure.

If these steps fail to improve electrode response, replace the electrode.

CRYSTAL FORMATION IN REFERENCE TUBE

The electrode solution for the reference portion of the electrode contains 2.2 N potassium chloride. Thus, temperature variations may cause crystals to form (which may interfere with free flow of electrode solution to the reference junction). These deposits are removed easily by immersing the area where crystals have developed in warm water (approximately 30°C or 86°F) for three to five minutes. If the crystals develop near the tip, immerse the electrode tip (or the entire electrode if necessary). If the area of blockage is unknown, the entire electrode and tube can be immersed. Do not immerse the instrument connectors. After the blocked area has been immersed for a few minutes, turn the PRIMING KNOB counterclockwise to flush electrode solution through the system. If crystals are present in the electrode solution cartridge, remove the cartridge from the instrument and immerse the cartridge in warm water. Shake gently until all crystals are redissolved.



PART 4. TROUBLESHOOTING

Hach One pH Meter troubleshooting is easy. Four different tools are available. First, the offset and slope may be monitored using the Review key. Second, prompting indicators are used to display potential problems. Third, error codes have been designed to notify the user when the measurements are not performed accurately either due to operator error or to probe characteristic changes. These error codes are listed below. Fourth, a Troubleshooting Guide is provided. Common problems are solved easily by following these simple steps.

REVIEW KEY

In the pH mode the Review key will display, when pressed, the offset in millivolts in the display and the slope in millivolts per pH unit in the temperature display. For the Hach One Combination pH Electrode expect to see offset voltages deviating from 0.0 by 15 millivolts or less. The expected slope may deviate from -59.2 millivolts per pH unit by five percent. Values greater than these indicate the meter is unable to detect stable conditions. One alternative is to wait for 30 to 60 seconds before pressing the Standard key during a calibration. Another response is to clean the electrode as described in Part 3—Normal Electrode Cleaning.

REVIEW

PROMPTING INDICATORS

UNSTABLE READINGS



During a calibration the pH indicator will flash indicating the reading is not yet stable.



During a pH measurement the probe indicator, in pH mode will flash if the pH reading is unstable.



Both of these conditions may be corrected by verifying there is adequate electrode solution at the junction and no air bubbles are present in the electrode solution tubing or glass bulb. Air bubbles in the electrode solution tubing are the most common problem.

The probe indicator will remain on if the calibration offset deviates from 0.0 mV by 60 to 120 mV and/or the slope deviates from the ideal slope of -59.2 mV/pH unit by 15 to 30%. Use the Review key to note the offset and slope. Correct a wrong offset by a one-buffer calibration. Correct a wrong slope and offset by a two-buffer calibration or return to the factory-set calibration.



LOW BATTERY

The battery indicator lights when the battery is low. When the voltage becomes too weak to operate the meter circuits, the instrument will turn itself off after two seconds while maintaining calibration data in memory. To save the calibration values during battery replacement:



1. Turn the meter off.
2. Have a replacement battery ready.
3. Switch batteries within 15 seconds.

UNCONNECTED TEMPERATURE PROBE



The °C indicator will flash if the temperature probe is not connected to the meter.

ERROR CODES

Error codes will appear as E followed by a value of one to eight. Each error code is listed with a description of the cause and the possible corrective steps.

E 1 The probe voltage reading is out of range in the pH mode. It is greater than 19.99 pH or less than -1.99 pH. This will occur when the meter is turned on and/or the electrode is removed from a solution. It may correct itself when placed into a solution. If E 1 appears while in a solution, air bubbles in the electrode solution tubing are probably the cause. Air bubbles are removed by dispensing more electrode solution with the Dispenser Button. More air bubbles can be removed by turning the Priming Knob counterclockwise. Other corrective steps may be to change to mV mode or connect the electrode to the meter. In rare cases, air bubbles in the glass bulb are the cause; see Electrode Installation, Step 2.

E 2 The deviation from the ideal pH slope of -59.2 mV/pH unit is greater than 30%. Recalibrate with a two-buffer calibration or use previous calibration. To use the previous calibration turn the meter off, turn it on and press the pH key. The factory-set calibration may be used by removing the battery for at least five seconds while the meter is on.

E 3 The probe mV offset is greater than 120 mV or less than -120 mV. Recalibrate or use previous calibration. To use the previous calibration, turn the meter off, turn it on and press the pH key. The factory-set calibration may be used by removing the battery for at least five seconds while the meter is on.

E 4 The pH reading has not been recognized as one of the 4.01, 7.00 or 10.00 pH standards in the automatic buffer recognition mode. If appropriate, try the standard again by putting the electrode in a different solution.

E 5 Both calibration buffers have the same nominal pH value. The two pH buffers must be at least 1 pH unit apart. Recalibrate with different buffers or use previous calibration. To use the previous calibration, turn the meter off, turn it on and press the pH key. The factory-set calibration may be used by removing the battery for at least five seconds while the meter is on.

E 6 The voltage is read as less than -50 mV or greater than 50 mV while the meter is being zeroed in millivolt mode. Verify if the shorting clip was installed correctly and redo the Millivolt Zeroing Procedure. If still unable to zero, contact the Hach Factory Service Center.

E 7 The temperature is outside the range for automatic buffer recognition, 0 to 60°C. There are three different conditions that would cause this error code.

1. The electrode was placed in a buffer with a temperature outside of the range 0 to 60°C.

- a. Use the manual mode and input the correct temperature.

OR

- b. Immerse the electrode tip into a buffer with an appropriate temperature and press the Standard key.

2. The temperature probe was not plugged in. The °C will be flashing as well. Plug in and press the Standard key.

3. The temperature probe is defective. The °C will be flashing even though it is plugged in.

- a. Replace the probe.

OR

- b. Follow the manual calibration procedure and input the correct temperature.

OR

- c. Use a separate temperature probe (Cat. No. 43976-00).

E 8 The millivolt reading is less than -1999 mV or greater than +1999 mV. Verify the probe is connected and follow the suggestions for Unstable Readings in the Prompting Indicators section.



TROUBLESHOOTING GUIDE

Step 1. Is the display working?

Press and hold **6**. Verify that all the segments are lighted. The display will appear as shown in Figure 12. Release **6**. Failure of all the segments to light at once does not mean the instrument will not operate properly. Occasionally, a few segments do not light during this test when they are still operable. You can check these segments by pressing the appropriate mode and calibrate keys that will activate the questionable segments. If they still fail, contact the factory service center for assistance. Refer to Repair Service.

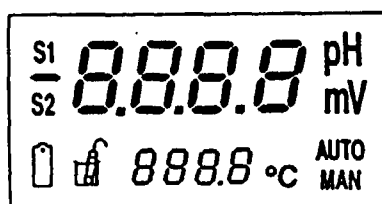


Figure 12. Display

Step 2. Are readings erratic?

In the event of a malfunction, verify that air bubbles have not stopped the diffusion of electrode solution at the junction. Five complete counterclockwise turns of the Priming Knob should purge the electrode solution tubing of all air bubbles. Air bubbles are the most common source of electrode malfunction.

Step 3. Is it the meter or the electrode?

Verify that the meter is operating properly by zeroing the instrument with a steel paper clip as described in Part 2, Millivolt Zeroing. The meter is the least common source of error. If the meter zeros, the most probable source of error is the electrode.



Step 4. How to check the electrode.

1. Visually inspect the electrode for air bubbles in the reference junction and glass bulb. Air bubbles in either location will cause the electrode to malfunction. To remove air bubbles from the reference junction, use the Priming Knob to dispense additional electrode solution. To remove air bubbles from the glass bulb, shake the electrode down as you would a clinical thermometer.
2. Visually inspect the glass bulb for cracks or breakage. The electrode must be replaced if the glass bulb is cracked or broken.
3. Is the electrode solution flowing through the reference junction? Immerse the glass bulb in the electrode tip in a glass beaker of clear water and depress the Dispenser Button. You should see electrode solution falling from the electrode tip to the bottom of the beaker.

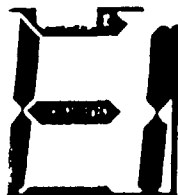
If the electrode solution tubing is plugged, use a syringe attached to the electrode solution tubing connector to force air through the junction. Or, soak the probe in warm water.

4. Check the electrode electrical connections. Place the electrode in a solution of known pH. Gently flex the cable at the top of the electrode and at the BNC connector. Erratic readings at this point indicate a poor cable connection. The electrode must be replaced.

OTHER POSSIBLE CONDITIONS

DISPLAY

The display shows only partial digits, behaves in an erratic manner or if the instrument cannot be turned off with the power switch. Correct by removing the battery for a few seconds while the meter is on to restore the factory-set default conditions. If the condition persists, contact the Hach Factory Service Center.



SLOW RESPONSE

Low ionic-strength samples will cause a slower than normal response time, perhaps up to three minutes, in weakly buffered solutions from 10^{-3} M buffer to pure water. Conventional electrodes with porous junctions may require up to 40 minutes in similar low ionic-strength solutions. Clean the electrode glass bulb with a soft brush or towel. The glass bulb is easily scratched impairing electrode response. Therefore, clean carefully. Remove organic material from the electrode with acetone or alcohol. If acetone or alcohol is used, soak the electrode in deionized water for at least 30 minutes to quiet electrode response.

Response time may slow temporarily when the ionic strength of the measured solution changes greatly. The response time may be faster if the electrode is conditioned prior to use in a solution of approximately the same ionic strength. The length of time required to condition the electrode for different applications must be determined by the user. Two signs that conditioning is necessary are a probe indicator that flashes longer than usual and/or a slow drifting measurement over time. Drift may be due to volatile acids or bases in the sample, or absorption of atmospheric carbon dioxide, sulfur dioxide and ammonia.

INCORRECT TEMPERATURE READINGS

Verify the temperature probe is connected to the meter. Unplug the temperature probe and enter the desired temperature manually. Other alternatives would be to replace the electrode or substitute a separate temperature probe. If the °C flashes when the temperature probe is plugged in, the probe is defective. Either replace the probe or input the correct temperature with the Edit keys.



If the problem is still unknown, contact the Hach Factory Service Center, 800-247-3990.



PART 5. SERVICE

REPLACEMENT ITEMS AND ACCESSORIES

REPLACEMENT ITEMS

Description	Cat. No.
Portable Hach One pH Meter, Complete Kit	43800-00
Hach One Combination pH Electrode	44200-51
with Temperature Sensor, BNC Connector and (36") Cable	
Electrode Solution Cartridge	21950-01
Beaker, 100 mL (2 required)	22994-42
Battery, 6 volt J type	43816-00
or Duracell #7K67, Varta #4018T, Eveready #539	
Buffer Powder Pillows, pH 4.01 (red) and pH 7.00 (yellow)	22992-64
10 each	
Instruction Manual	43800-88
Clipper, Large	968-00
Carrying Case	43818-00

OPTIONAL REAGENTS

Buffer, Powder Pillows	
pH 4.01, 50/pkg*, color-coded red	22269-66
pH 5.00, 15/pkg	14097-95
pH 6.00, 15/pkg	14055-95
pH 6.86, 15/pkg	14098-95
pH 7.00, 50/pkg*, color-coded yellow	22270-66
pH 8.00, 15/pkg	14097-95
pH 9.00, 50/pkg*	14107-66
pH 9.18, 15/pkg	14102-95
pH 10.00, 50/pkg*, color-coded blue	22271-6
Buffer Solutions	
pH 4.00, 473 mL (pt)*, clear solution	12223-11
pH 4.00, 473 mL (pt), color-coded red	22834-11
pH 7.00, 473 mL (pt)*, clear solution	12222-11
pH 7.00, 473 mL (pt), color-coded yellow	22835-11
pH 10.00, 473 mL (pt)*, clear solution	12221-11
pH 10.00, 473 mL (pt), color-coded blue	22836-11
Hydrochloric Acid Standard Solution,	14812-16
0.1M, 0.45 mL (pt)	
Buffer Powder Pillows	14345-98
Electrode Solution,	191-16



OPTIONAL APPARATUS

BNC Shorting Cap	19024-00
Demineralizer Bottle, 177-mL (6 oz)	14299-00
Hach One Combination pH Electrode with BNC Connector and (36") cable without Temperature Sensor	44300-51
Ion Selective Electrodes	
Complete Fluoride Analysis Package	13034-01
Hach Fluoride Electrode, BNC Connector	44500-01
Requires Hach One Reference Electrode	44250-00
Hach Sodium Combination Electrode, US Standard Connector	21674-00
Hach Nitrate Electrode, US Standard Connector	22339-00
Requires Double Junction Reference Electrode	22558-00
US Standard to BNC Adapter for Sodium and Nitrate Electrodes	18809-00
Rack, with 10 sample bottles and closure	18614-00
Scoop, Measuring, 3.5 cc	17044-00
Spatula, stainless steel	561-62
Stainless Steel Temperature Probe	43976-00
316 stainless steel, thermistor sensor, interchangeable. Includes BNC shorting cap.	
Thermometer, armored, -10 to 100°C	1877-01



HOW TO ORDER

Mail Orders

Hach Company World Headquarters
P.O. Box 389
Loveland, Colorado 80539 U.S.A.

Telephone Orders

Toll-free number: 800-227-HACH in continental U.S.A., Puerto Rico,
Hawaii and U.S. Virgin Islands. In Alaska and Canada, call collect:
303-669-3050. (Canadians should ask for the International Sales
Department.)

For bulk quantities and custom chemical products

Toll-free number: 800-247-3990 (In Iowa, call 515-232-2533)

For factory service see Repair Service section.

For all other questions not related to ordering or service contact:

HACH WORLD HEADQUARTERS

Toll-Free: 800-227-HACH (Continental U.S.A.)

(In Colorado and Outside Continental U.S.A. 303-669-3050.)

TWX (TELEX) ORDERS 910-930-9038 (HACH LVLD)

Please specify:

Catalog number

Brief description of item

Quantity and size

Shipping address

Billing address

Purchase order number

Your name and phone number

Call or write for free quotations.



REPAIR SERVICE

If you need factory service on your instrument, please write or call the Hach Factory Service Center first for instructions, call toll-free 800-247-3990.

Hach Factory Service Center
100 Dayton Ave.
P.O. Box 907
Ames, IA 50010
(515) 232-2533 (Iowa)

Regional Service Offices
57th St., Lindbergh Pkwy.
P.O. Box 389
Loveland, CO 80539
(303) 669-3050

Hach Company
7854 Browning Rd.
Pennsauken, NJ 08109
(609) 662-0034

Hach Company
1901 Production Rd.
Ft. Wayne, IN 46808
(219) 482-3015

Hach Company
2046-I West Park Place
Stone Mountain, GA 30087
(404) 498-0511

Hach Company
46711 Fremont Blvd.
Fremont, CA 94538
(415) 651-1120

Hach Company
13003 Southwest Freeway Suite 150
Stafford, TX 77477
(713) 240-8066

If you are located in Canada, Latin America, the Caribbean, the Far East or the Pacific Basin, please contact Hach Company, World Headquarters, P.O. Box 389, Loveland, Colorado 80539, U.S.A.. Telephone (303) 669-3050, TWX (Telex) 910-930-9038. Customers located in Europe, the Middle East or Near East, or in Africa, please contact Hach Europe, S.A./N.V., B.P. 51, B5000 Namur 1, Belgium. Telephone (081)44.53.81, Telex 846-59027.



WARRANTY

Hach warrants the Hach One pH Meter and the Hach One Combination Electrode against defective materials or workmanship for one year from the date of shipment. Warranties do not apply to limited life components such as batteries.

Hach's Terms and Conditions of Sale are printed on the back of Hach invoices.

CLAIMS

We take extreme care to fill and pack orders properly. If errors or damages do occur, report shipping damage to the carrier immediately and contact the Hach Factory Service Center as soon as possible (always within two weeks of receipt).

RETURN OF ITEMS

Authorization must be obtained from Hach before returning items for any reason. For credit or replacement, call toll-free 800-247-3990. All "Freight Collect" shipments of returned merchandise must be refused.

LIMITS OF USAGE

Our chemicals are offered for laboratory and manufacturing use ONLY. They may not be used as drugs, cosmetics or food additives.

APPENDIX A

THEORY OF pH MEASUREMENT

Technically, pH is a measure of the hydrogen ion activity in a solution and is defined as: $-\log_{10} a_{H^+}$, where a_{H^+} is the activity of the hydrogen ion. Practically, this means that at pH 0, the hydrogen ion concentration is 1×10^0 times greater than at pH 14. This also means the hydroxyl ion concentration at pH 14 is 1×10^0 times greater than at pH 0. When the hydrogen and hydroxyl ions are present in equal numbers (the neutral point), the pH is 7. pH values from 0 to 7 are termed acidic and those from 7 to 14 are termed basic. It is important to note that a pH change of one unit (for instance from pH 6 to pH 7) actually is a factor-of-10 change in hydrogen ion concentration.

The glass membrane of a pH electrode responds to the hydrogen ion activity by developing an electrical potential at the glass/liquid interface. At a constant temperature, this potential varies linearly with the pH of the solution being measured. The change in potential per pH unit is termed the slope of the electrode. The slope of the electrode increases linearly with temperature.

Potential inside the pH electrode is fixed by the filling solution, and the reference electrode potential is constant. For these reasons, any change in the potential of the electrode system at a given temperature will be due to changes in the pH of the solution being measured.

Effects of temperature on pH measurements depend on the reference electrode used, pH of the solution within the pH electrode and pH of the test solution. At a certain pH, temperature will have no effect on the potential of the electrode system. This is known as the isopotential point. Also, at some pH level, the system will exhibit no potential. This is known as the zero potential point. Both the isopotential and zero potential points are features designed into electrodes. Hach electrodes are designed so the isopotential and zero potential points are at pH 7 to minimize temperature effects at this calibration point.

CONVENTIONAL ELECTRODE DESIGN

Electrodes used in pH measurement usually consist of a glass half-cell and a reference half-cell. The glass half-cell is a thin glass membrane separating two solutions. The outer solution is the sample solution. The internal solution is enclosed with the glass membrane and has a known pH. An electrical potential difference develops between the two solutions. A second half-cell, or reference electrode, is necessary to complete the measurement. The reference half-cell contains a solution of known potential. The sample solution is necessary to complete the measurement and provide a potential difference.

The function of the reference half-cell is to maintain a constant potential with respect to the sample solution regardless of any change in ionic strength or pH of the sample. Thus, the reference half-cell maintains constant potential to act as a reference standard and the glass half-cell has a potential difference depending on the pH of the sample solution. Glass and reference half-cells may be contained in two separate enclosures or electrodes, or they may be combined into a single enclosure and called a combination electrode; see Figure 13.

Most electrode pH measurement problems are related to the failure of the reference half-cell to maintain constant potential. The problem is most obvious when making pH measurements on two sample solutions with a great difference in ionic strength. An example would be when a pH meter is calibrated with buffers of high-ionic strength and followed by measurement of a low ionic-strength sample, such as drinking water. The problem also exists in less extreme cases but errors in pH measurement result just the same. Figure 14 shows the variation in junction potential with log buffer strength for an aged Hach One and an aged porous ceramic junction electrode. The Hach One maintained a nearly constant potential, but the conventional electrode varied up to 32 mV as the sample changed from normal strength buffer to pure water. At 58 mV/decade this change would result in a difference of 0.5 pH units. To maintain a constant potential, the reference half-cell contains a concentrated salt solution, commonly potassium chloride (KCl). The reference solution must be able to flow freely to the sample from the half-cell via diffusion or through a flowing junction.

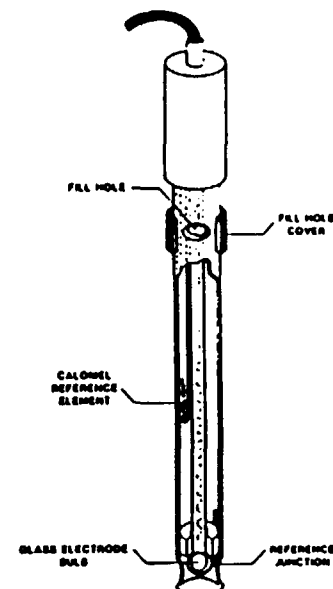


Figure 13. Conventional Electrode

pH measurements on two sample solutions with a great difference in ionic strength. An example would be when a pH meter is calibrated with buffers of high-ionic strength and followed by measurement of a low ionic-strength sample, such as drinking water. The problem also exists in less extreme cases but errors in pH measurement result just the same. Figure 14 shows the variation in junction potential with log buffer strength for an aged Hach One and an aged porous ceramic junction electrode. The Hach One maintained a nearly constant potential, but the conventional electrode varied up to 32 mV as the sample changed from normal strength buffer to pure water. At 58 mV/decade this change would result in a difference of 0.5 pH units. To maintain a constant potential, the reference half-cell contains a concentrated salt solution, commonly potassium chloride (KCl). The reference solution must be able to flow freely to the sample from the half-cell via diffusion or through a flowing junction.

LOG BUFFER CONCENTRATION (M)

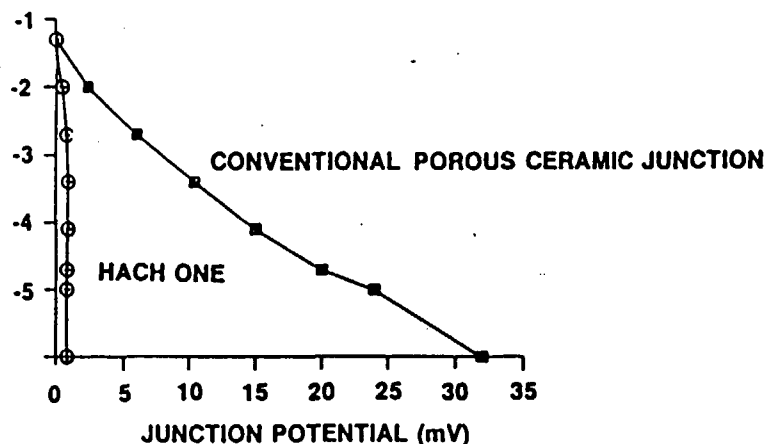


Figure 14. Junction Potential Compared to Buffer Strength

The porous junction of a conventional reference half-cell is made of ceramic or fiber. With time, the junction will become clogged with silver chloride or contaminants, causing large variation in the junction potential. In addition, reference solution can be contaminated or diluted by back diffusion of sample into the junction. Particulate contaminants may be introduced into refillable electrodes in the filling solution. Clogged or fouled junctions can cause drift along with inaccurate, noisy, erratic and sluggish pH measurements. The performance of conventional porous junctions deteriorates as they age because of clogging.

Hach One Electrodes solve this clogging problem because they use a continually renewed liquid junction; see Figure 15. The liquid junction is made of a free-flowing reference solution that is continually renewed by a free-flowing reference junction. The free-flowing reference junction is made of a free-flowing reference solution to give the most accurate results because the junction potential is stable.

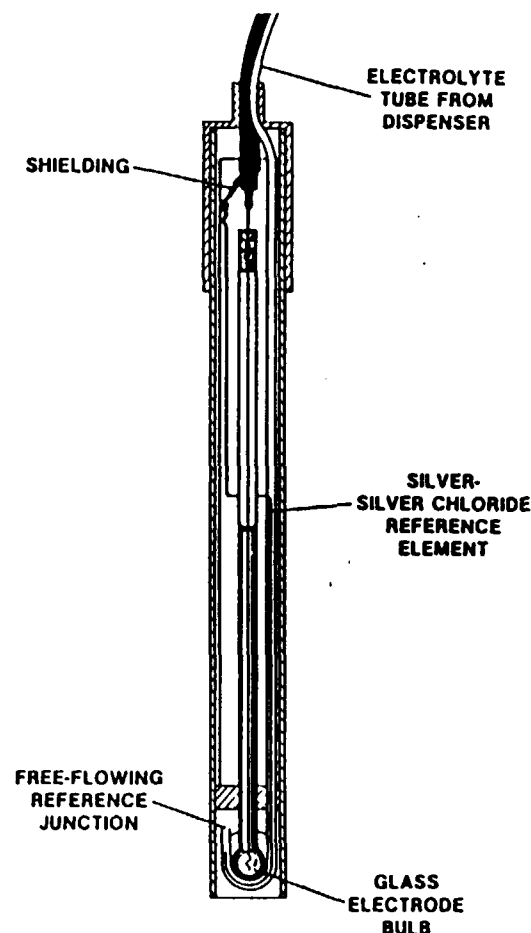


Figure 15. Hach One Combination pH Electrode

If the junction potential changes with the sample's ionic strength, the changes are read as part of the potential due to the hydrogen ion activity. This can cause an error in the pH reading. Figure 16 shows an aged conventional porous ceramic junction electrode (top) equilibrated in deionized water until a steady reading was obtained. The ionic strength was changed by adding a neutral salt, KCl. The apparent pH reading changed by 0.4 pH units. In the bottom graph the same electrode was retested, but with the reference electrode replaced by an aged Hach One reference electrode. Addition of KCl has little effect on the pH reading because the reference junction is stable.

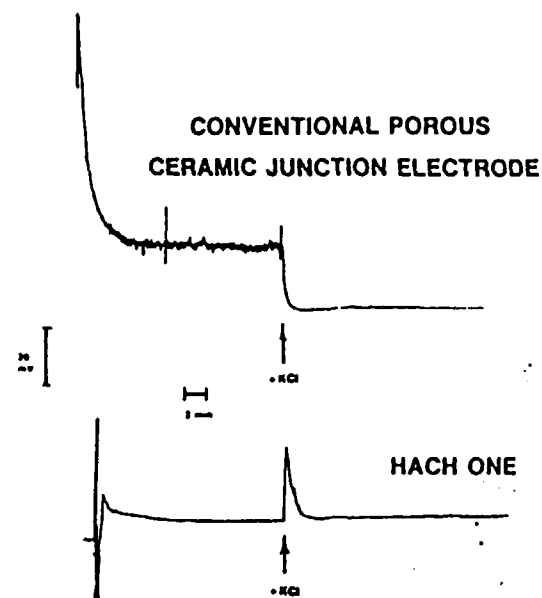


Figure 16. Influence of Ionic Strength on pH Electrode

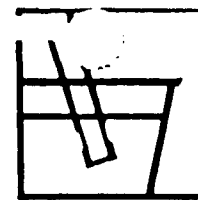
CHECKING ELECTRODE RESPONSE

The proper electrode response is relatively easy to check. Begin with a 6.86-pH buffer prepared by adding 3.388 grams of K_2PO_4 (potassium phosphate, monobasic) and 3.533 grams of Na_2HPO_4 (sodium phosphate, dibasic) to deionized water and dilute to one liter. Or, dissolve the contents of one Hach Buffer Powder Pillow (Cat. No. 140987) to 50 mL of deionized water. Label this solution A.

Pipet 5 mL of solution A to a mixing cylinder and add deionized water for a total volume of 50 mL. Label this solution B. Solution B is a 1-in-10 dilution of solution A.

Use solution A as the first buffer to calibrate the pH meter at 6.86 pH, 25°C.

Use a second buffer at pH 4.01 to calibrate the meter. The 4.01 pH buffer may be prepared by adding 10.12 grams of potassium hydrogen phthalate (potassium acid phthalate) to deionized water and diluting to one liter. Or, dissolve the contents of one Hach Buffer Powder Pillow (Cat. No. 22269) in 50 mL deionized water.



Thoroughly rinse the electrode(s) well with deionized water and measure solution B. If the reference junction is functioning properly and junction potentials are well-behaved, the meter should read 7.06 ± 0.01 . In one recent study conducted by John Illingworth,* 30 electrodes were selected at random from seven laboratories. Twenty-four of the electrodes failed the test. Hach researchers found similar results. Errors as large as ± 0.5 pH units were observed among older combination ceramic junction electrodes. Of the electrodes tested by Hach, only the Hach One Combination pH Electrode gave the correct pH value.

INFLUENCE OF IONIC STRENGTH

Illingworth also reported changes in sample ionic strength caused large pH errors in used combination electrodes.

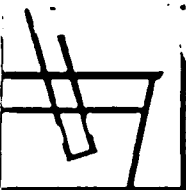
He found a varying junction potential gave rise to an error of 0.2 pH per ten-fold change in buffer strength. Davison and Woof† tested electrodes with various dilute solutions and natural waters and found errors up to 2.6 pH.

A simple test demonstrating the influence of ionic strength on pH measurement is performed as follows.

1. Calibrate the electrode(s) as outlined in the above Checking Electrode Response section.
2. Place the electrode into 250 mL of stirring deionized water and allow the electrode response to stabilize. Note the pH reading.
3. Add 50 mg of ultrapure solid KCl. Allow the electrode response to stabilize. Note the pH reading.

*Illingworth, John A., "A Common Source of Error in pH Measurements," *Biochemical Journal* (1981) 195, 259-262. To receive a free reprint write or call Hach and ask for literature number 6061.

†Davison, W.; Woof, C., "Performance Tests for the Measurement of pH with Glass Electrodes in Low ionic-strength Solutions Including Natural Waters," *Analytical Chemistry* (1985), 57, 2567-2570.



The addition of the KCl changes the sample from a low ionic-strength solution to a moderate ionic strength solution. In one study† the above test was performed with the Hach One and other conventional electrodes. After the addition of the KCl, the Hach One stabilized at the same level as before the addition of KCl. Porous junction electrode potentials decreased by as much as 0.42 pH (25 mV); see Figure 16. The addition of ultrapure KCl to deionized water provides a quick, easy-to-perform performance check of the reference junction in an electrode. If the junction is allowing adequate flow or diffusion of electrode solution, the potential will change very little upon addition of KCl, less than 0.08 pH (5 mV). The Hach One is designed to provide junction potential stability, giving more accurate measurements, especially with low ionic-strength samples. Try this test with conventional porous junction electrodes after they've been in use for a few weeks!

†Kopelove, Alan B.; Franklin, Stanley J., submitted for publication, "Performance Tests of Reference Junctions in Combination pH Electrodes," Hach Company, Loveland, Colo., 1986.

APPENDIX B

RAINWATER AND ULTRAPURE WATER

The Hach One is ideally suited for rainwater and ultrapure water pH measurements. This procedure consists of three parts, calibration, control and measurement, in that sequence.

The electrodes should be conditioned in deionized water when not in use.

CALIBRATION

1. Calibrate the instrument by following instructions in Part 3, pH Calibration. Two buffer solutions are recommended (for instance, pH 4.01 and pH 7.00).

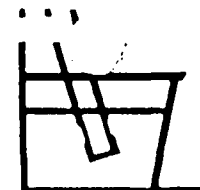
Use either Hach Powder Pillows or National Bureau of Standards (NBS) Standard Reference Materials.

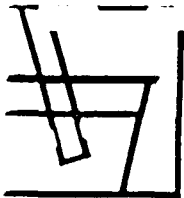
SRM 185e (pH(s) 4.004 at 25°C) and SRM 186Ic/186IIc (pH 6.863(s) at 25°C) are available for purchase from:

Office of Standard Reference Materials, NBS, Washington, DC 20234

CONTROL (OPTIONAL)

2. If required, electrode performance and calibration can be verified with rainwater reference samples such as NBS Simulated Rainwater, Reference Material 8409.
 - a. Insert the electrode(s) into a clean 50-mL beaker containing 10 to 20 mL of the prepared rainwater reference solution.
 - b. Dispense electrode solution and gently swirl or stir the sample. Stirring the sample continuously is recommended.
 - c. When the reading has stabilized, record the pH value. Calculate the difference between the assigned pH value of the reference and the measured value. The difference should be less than 0.05 pH units at the calibration and control sequence.

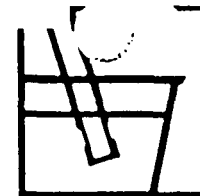




MEASUREMENT

3. Rinse electrode(s) thoroughly with deionized water.
4. Insert the electrode(s) into a clean 50-mL beaker containing 10 to 20 mL of sample. The glass bulb and junction tube must be immersed.
5. Dispense electrode solution and gently swirl or stir the sample.
6. Record the pH value after the reading stabilizes. This may take several minutes. Record the sample temperature and report it along with the pH.
7. The Hach One Electrode can be conditioned for low ionic-strength samples by immersing the electrode tip in deionized water and minimizing exposure to concentrated solutions such as buffers.

Reagents and Apparatus, See Part 5, Replacement Items and Accessories.



SOIL pH

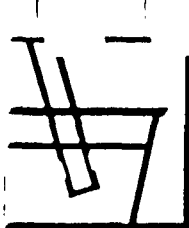
Buffer pH, Lime Requirement
Using Lime Requirement Buffer 1 Powder
For 1:2.5 Soil Slurry

CALIBRATION

1. Calibrate the instrument by following instructions in Part 3, pH Calibration. Two buffer solutions are recommended (for instance, pH 4.01 and pH 7.00).

MEASUREMENT

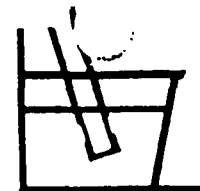
2. Fill a 3.5-cc scoop with screened soil, tap the handle to settle the soil and strike off the excess with a spatula. Transfer two scoopfuls of each soil sample to bottles with screw caps; see Note A. Fill each bottle to the 25-mL mark with deionized water. Cap the bottle and shake for 30 seconds. Allow the sample to stand for at least 10 minutes after shaking.
3. Immerse the electrode in deionized water. Depress the DISPENSER BUTTON once to dispense reference solution. Then, immerse the electrode in the sample and stir briefly. Read the sample pH on the meter. This reading is the soil water pH (pH_w); see Note B.
4. Add the contents of one Lime Requirement Buffer 1 Powder Pillow, Cat. No. 14345-98, to the sample bottle. Cap the bottle and shake for 30 seconds. Allow the sample to stand for 10 minutes.
5. Immerse the electrode in deionized water and depress the DISPENSER BUTTON once to dispense reference solution. Then, immerse the pH electrode in the sample bottle, stir briefly with the electrode and read the meter. This reading is the soil buffer pH (pH_b).
6. After sample measurement, rinse the electrode with deionized water. See Part 3, Maintenance, for proper storage.



7. Consult the Lime Requirement Table to find the limestone recommendation corresponding to the buffer pH of each soil; see Note C.

Lime Requirement Table: Pure Limestone (as CaCO_3) Required

Buffer pH	Tons/Acre—8" Depth	
	To pH 7	To pH 6.5
6.8	0.1	0.1
6.7	0.7	0.6
6.6	1.2	1.0
6.5	1.9	1.6
6.4	2.7	2.3
6.3	3.4	2.9
6.2	4.2	3.6
6.1	5.1	4.3
6.0	5.7	4.8
5.9	6.7	5.7
5.8	7.5	6.4
5.7	8.4	7.1
5.6	9.1	7.7
5.5	9.8	8.3
5.4	10.7	9.1
5.3	11.5	9.8
5.2	12.4	10.5
5.1	13.1	11.1
5.0	13.9	11.8
4.9	14.7	12.5



NOTES

- A. Use round bottles with screw caps and a capacity of at least 30 mL. Prior to the test, use a 25-mL graduated cylinder and add 25 mL of deionized water to each bottle and mark the 25-mL level in the bottle. A special shaker rack and 10 sample bottles, Cat. No. 18614-00, are available from Hach.
- B. If the soil water pH is 6.5 or higher, there is no need to conduct the buffer pH test because the results will be meaningless.
- C. Table values are based on pure, fine CaCO_3 . To determine the requirement of agricultural limestone or other liming materials, divide the table value by the CaCO_3 assay percentage of the liming material being used.

Reagents and Apparatus, See Part 5, Replacement Items and Accessories.

Hach One is a Hach Company trademark.

APPENDIX C. TEMPERATURE VERSUS pH

Table 1. Temperature (°C) Versus pH of Hach Buffers

pH Name Cat. No(s).	Powder Pillows										Solutions			
	4.01	5.00	6.00	6.86	7.00	8.00	9.00	9.18	10.00	10.00	4.00	7.00	10.00	
22269*	14097	14055	14098	22270*	14079	14107	14102	22271*			22834*	22835*	22836*	
											12223	12222	12221	
0	4.00	5.10	6.08	6.98	7.14	8.17	9.28	9.46	10.30		4.00	7.14	10.25	
5	4.00	5.06	6.04	6.95	7.10	8.13	9.21	9.39	10.23		4.00	7.10	10.18	
10	4.00	5.03	6.02	6.92	7.07	8.09	9.15	9.33	10.17		4.00	7.06	10.12	
15	4.00	5.01	6.01	6.90	7.04	8.06	9.09	9.28	10.11		4.00	7.03	10.06	
20	4.00	5.00	6.00	6.88	7.02	8.03	9.04	9.22	10.05		4.00	7.00	10.00	
25	4.01	5.00	6.00	6.86	7.00	8.00	9.00	9.18	10.00		4.01	6.98	9.94	
30	4.01	5.00	6.00	6.85	6.99	7.98	8.96	9.14	9.96		4.01	6.97	9.89	
35	4.02	5.01	6.01	6.84	6.98	7.96	8.92	9.10	9.92		4.02	6.95	9.86	
40	4.03	5.01	6.02	6.84	6.98	7.95	8.89	9.07	9.88		4.03	6.95	9.82	
45	4.05	5.02	6.03	6.83	6.98	7.95	8.86	9.04	9.85		4.05	6.95	9.79	
50	4.06	5.04	6.04	6.83	6.98	7.95	8.83	9.01	9.82		4.06	6.94	9.75	
55	4.07	5.06	6.06	6.83	6.98	7.95	8.81	8.98	9.79		4.07	6.94	9.71	
60	4.09	5.08	6.08	6.84	6.99	7.96	8.79	8.96	9.76		4.09	6.95	9.68	

ed buffers

Date _____

Hach Company

P.O. Box 389
Loveland, CO 80539

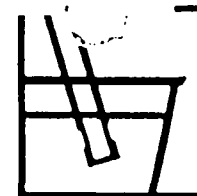
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800-525-5940

SHIP TO	1. FIRM _____
	ADDRESS _____
	CITY _____ STATE _____ ZIP _____
	TO ATTENTION OF: _____
	PHONE NUMBER _____ DEPT. _____
	<input type="checkbox"/> Send C.O.D. <input type="checkbox"/> Prefer to send check with order. Will pay shipping charges on invoice. <input type="checkbox"/> Charge purchase on open account: Hach Account No. _____

BILL TO	2. Purchase Order Number _____
	FIRM _____
	ADDRESS _____
	CITY _____ STATE _____ ZIP _____
	TO ATTENTION OF: _____
	PHONE NUMBER _____ DEPT. _____

Name of Item	Size	Cat. No.

Signature _____



Date _____

Hach Company

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FORMER DEPT.

1.

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DEPT.

☐ **Send C.O.D.**

☐ Prefer to send check with order. Will pay shipping charges on invoice.
☐ Charge purchase on open account: **Hach Account No.**

☐ Charge purchase on open account: **Each Account No.**

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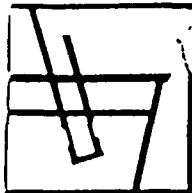
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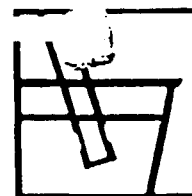


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INSTRUCTION MANUAL

S/N 701561

MODEL PI 101

Portable
Photoionization
Analyzer

hnu

©HNU Systems, Inc. 1986

The PI 101 is a non-destructive analyzer; work in a hood if toxic or hazardous gases are used. In the interest of greater international acceptance the HNU Model PI 101-100 Photoionizer has been certified by Sira Safety Services Ltd. to conform to Article 501-3 of the National Electrical Code to be non-incendiary for Class 1 Division 2, Groups A, B, C and D locations Effective July 25, 1984.

SIRA Approval #APL/33/84

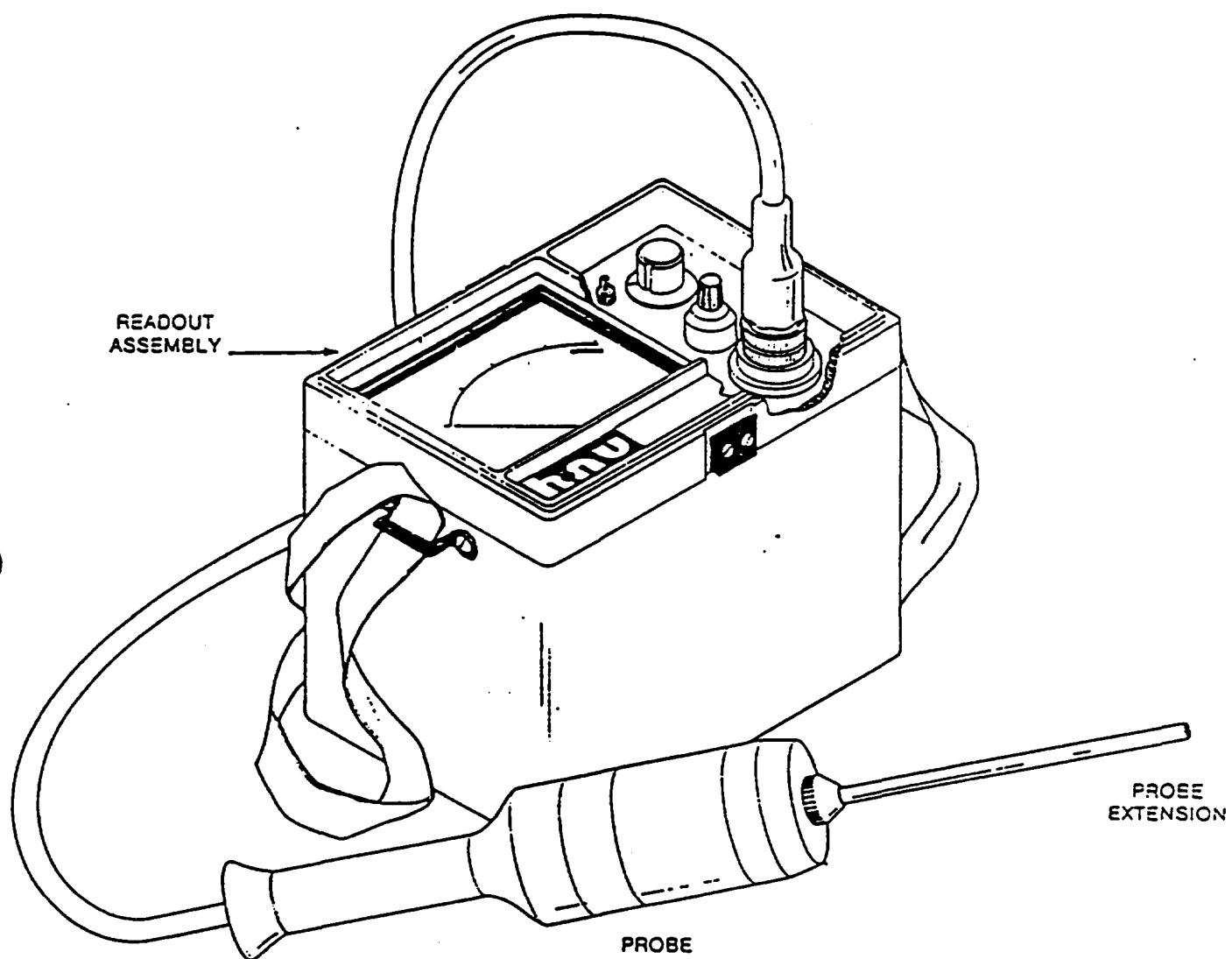


FIGURE 1-1
TRACE GAS ANALYZER
OPERATING CONDITION

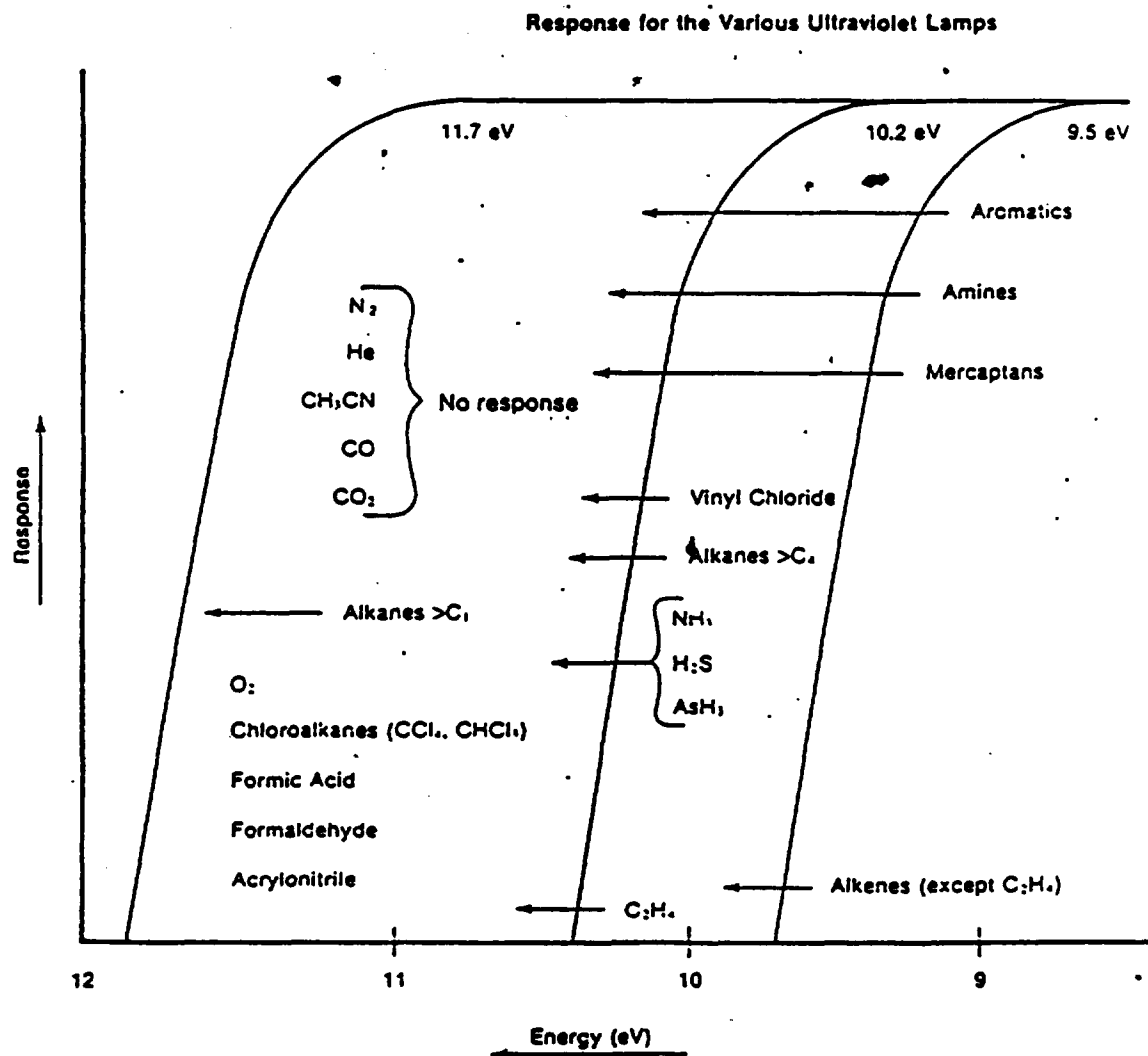


FIGURE 1-2
RESPONSE TO VARIOUS COMPOUNDS

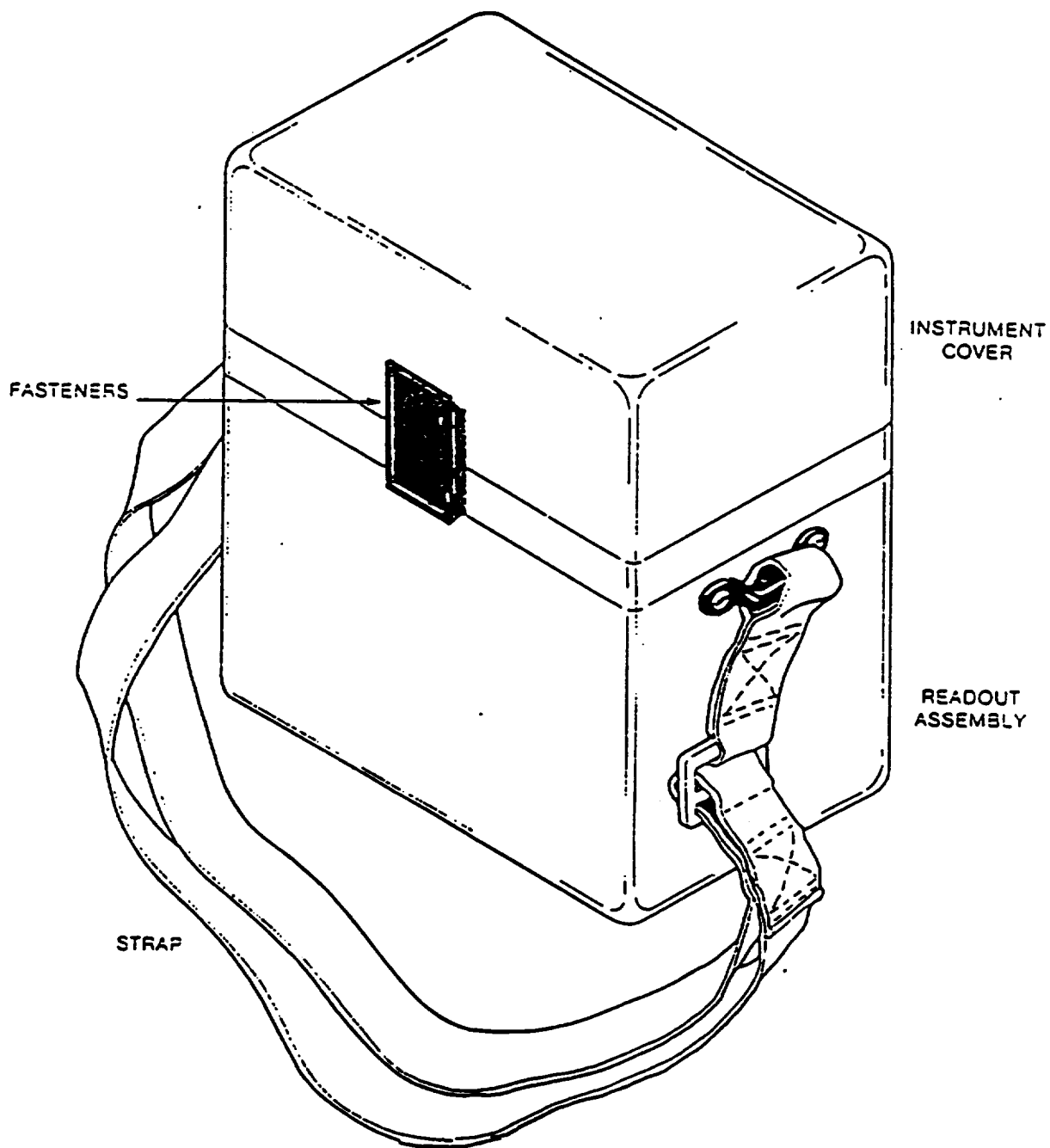


FIGURE 1-4
TRACE GAS ANALYZER

TABLE 1-1 cont.

Recharge time from full discharge	Full recharge - 12 to 14 hours
Recharge current	Max 0.4 amps at 15 V DC
Battery Charger Power	120 V AC, single phase, 50-60 cycle, 1.5 Amps

NOTE: * When equipped with 10.2 eV Probe with SPAN set at 9.8 and measuring benzene. Values will vary for other compounds and conditions.

SECTION 2

OPERATION

2.1 INTRODUCTION/UNPACKING

Unpack the instrument carefully. The carton will contain the housing, straps, battery charger, additional probes, regulator and cylinder if ordered, spare parts, supplies and a manual. Be sure all items are removed before discarding the carton.

Attached to the instrument is a warranty card which should be filled out completely and returned to HNU Systems.

2.2 CONTROLS AND INDICATORS

The controls and indicators are located on the front panel of the readout assembly (see Figure 2-1) and are listed and described in Tables 2-1 and 2-2.

OPERATING PROCEDURES

The following procedures are to be used in operating the analyzer:

- a. Unclamp the cover from the main readout assembly.
- b. Remove the inner lid from the cover by pulling out the two fasteners.
- c. Remove the probe, handle and cable from the cover. Attach the handle to the front part of the probe.
- d. Connect the probe cable plug to the 12 pin keyed socket on the readout assembly panel. Carefully match the alignment slot in the plug to the key in the connector. Screw down the probe connector until a distinct snap and lock is felt.
- e. Screw the probe extension into the probe end cap. The probe may be used without the extension if desired.
- f. Set the SPAN control for the probe being used (10.2, 9.5, or 11.7 eV) as specified by the initial factory calibration or by subsequent calibrations.

SECTION 1.2, EQUIPMENT DESCRIPTION cont.

The PI 101 is designed for use with interchangeable probes with lamps of different energies. The analyzer is ready for use simply by connecting the probe to the readout assembly, setting the proper SPAN pot value, and then zeroing the unit. Specific data is given in the calibration memo accompanying each probe.

The standard probe uses a 10.2 eV lamp. Two optional probes use 9.5 and 11.7 eV lamps. Lamps of different eV ratings, ion chamber and amplifiers are not interchangeable between probes.

Many applications make use of the principle that some compounds respond to the more energetic lamps and not to others. Figure 1-2 shows the responses for the analyzer with each of the three lamps. Literature explaining several such applications is available from HNU Systems Inc.

An optional audible alarm is available giving an 85 decibel signal when a set concentration is exceeded. The alarm setting is variable and can be set from 0 to 100% of full scale of the meter reading. Power for the alarm is provided by the battery and does not significantly affect the rated use time of the analyzer. The alarm is non-latching and is set by a screw adjustment, preventing inadvertent changes.

When in the stored condition, the probe is contained in the instrument cover (see Figure 1-3) which attaches to the readout assembly to form a single unit (see Figure 1-4).

An optional recorder is available that can be directly attached to the readout assembly. It uses impact paper with a 2" wide chart and a speed of 2"/hour. The recorder is powered by the instrument battery and provides hard copy of the data. The analyzer will operate for approximately 4 hours with the recorder attached. Mounting information and illustration is given in Section 8.

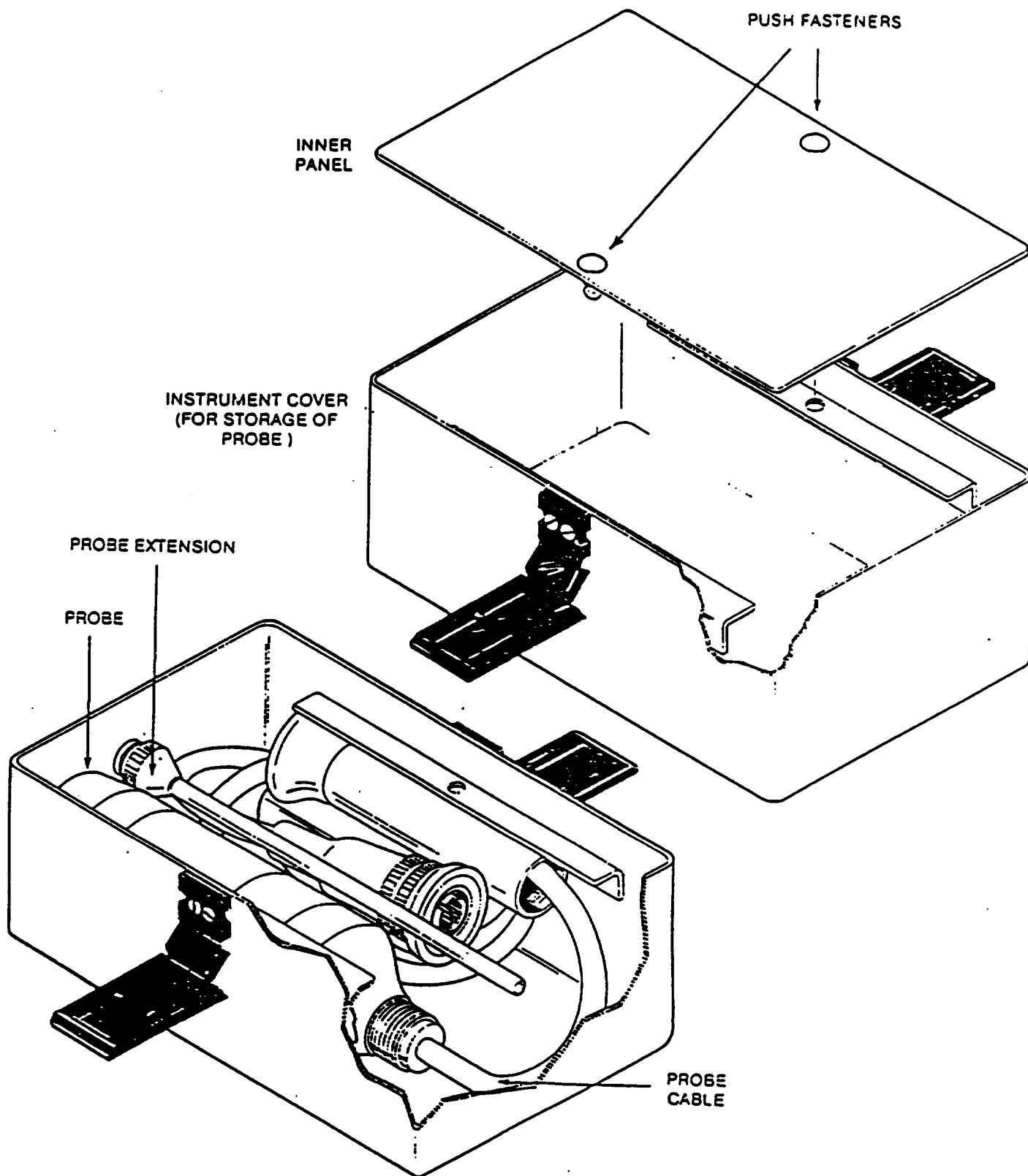
Specification data on the analyzer is given in Table 1-1. Physical characteristics of the equipment are given in Table 1-2.

TABLE 2-1

CONTROLS

Name	Position	Function
Function Switch	---	Controls the operation of the analyzer
	OFF	All operations OFF
	BATT (battery check)	Checks the condition of the battery. If the meter needle is in the green arc, the battery is charged. If not the battery should be recharged. Charging can be done in any position, best in OFF; see directions on charger.
	STANDBY	All electronics ON, ultraviolet (UV) light source OFF. This position conserves power and extends battery life. This position is used to set the analyzer zero position. (i.e. no UV light, no signal)
	0-2000	Sets range of meter at 0-2000 ppm.
	0-200	Sets range of meter at 0-200 ppm.
	0-20	Sets range of meter at 0-20 ppm.
ZERO	---	With the function switch in STANDBY position, this potentiometer is used to adjust the reading to zero.

NOTE: See Figure 2-1 for locations.



Repeated storage of probe in this manner is not recommended due to cable wear. Instrument cover may also be used for storing battery charger.

**FIGURE 1-3
PROBE STORAGE
INSTRUMENT COVER**

TABLE 2-2
INDICATORS AND DISPLAYS

Name	Function
Low Battery Indicator Light (red light) (see NOTE)	Illuminates when battery is discharged, indicates need for recharge. Do not use unit when this light is ON. Readings may be taken while battery is being recharged.
Meter (see NOTE)	Indicates concentration of measured gas.
Recorder (optional) (see Figures 2-1 And 8-3)	Provides a record of readings while analyzer operates unattended. Recorder inputs 0 to -5 V DC.

NOTE: See Figure 2-1 for locations.

TABLE 1-1
SPECIFICATION DATA

a. DESIGN FEATURES

Range settings	0 to 20, 200, 2000 ppm (other ranges available on request)
Lamp rating	10.2 eV standard, 9.5 or 11.7 eV optional
Audible alarm, low or high limit (optional)	85 db at 3'

b. CHARACTERISTICS (see NOTE)

Detection Range *	0.1 to 2000 ppm (parts per million by volume)
Minimum Detection Level *	0.1 ppm
Maximum Sensitivity *	0 to 20 ppm FSD at SPAN = 9.8 (full scale deflection) 0 to 2 ppm FSD at SPAN = 0.0
Repeatability *	+/- 1% of FSD
Linear Range *	0.1 to 400 ppm
Useful Range *	0.1 to 2000 ppm
Response Time	Less than 5 seconds to 90% of FSD
Ambient Humidity Operating Temperature, Ambient	up to 90% RH (relative humidity) -10 to 40 degrees C.
Operating Time on Battery, continuous use, without HNU recorder	Approximately 10 hours; at lower temperatures time is reduced due to effect of cold temperature on battery.
with HNU recorder (optional)	Approximately one half of normal time

SECTION 2.3, OPERATING PROCEDURES cont.

- n. The analyzer is now operational.
- o. Hold the probe so that the extension is at the point where the measurement is to be made. The instrument measures the concentration by drawing the gas in at the end of the extension, through the ionization chamber, and out the handle end of the probe.

WARNING

The instrument measures gases in the vicinity of the operator and a high reading when measuring toxic or explosive gases should be cause for action for operator safety.

- p. Take the reading or readings as desired taking into account that air currents or drafts in the vicinity of the probe tip may cause fluctuations in readings. Change the ranges as required.
- q. Check battery condition as required. If the Low Battery Indicator comes on, turn analyzer off and recharge.

CAUTION

Use only in an emergency with a low battery when on battery charge.

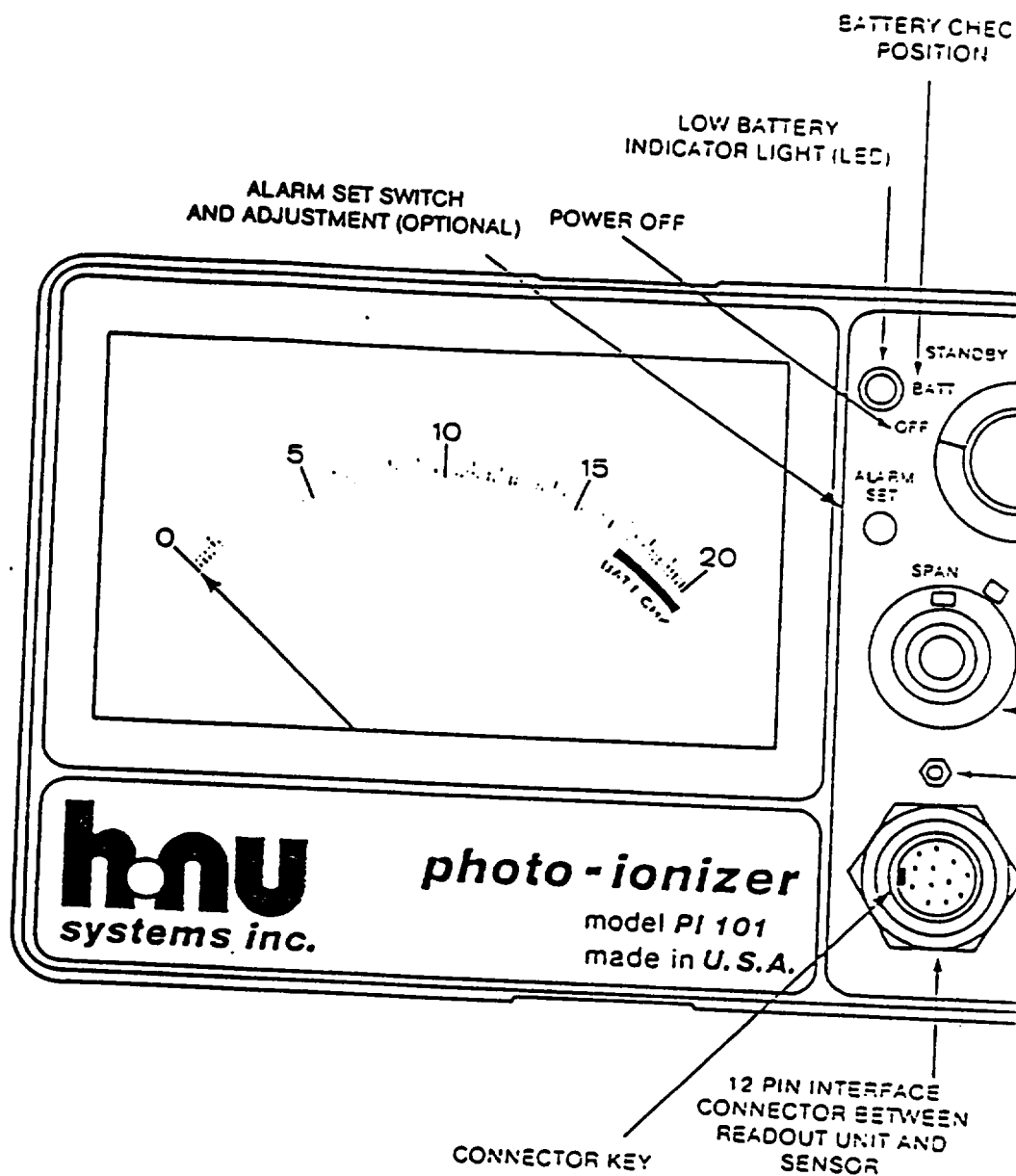


FIGURE 2-1
CONTROLS AND INDICATORS

TABLE 2-1 cont.

SPAN	---	This vernier is used to the amplifier direct read trace gas concentration in ppm. The of the setting the window decimal appearance dial. A lock at a specific
HI-VOLTAGE	---	This is a no microswitch
	Open	Switch is open not connected high voltage from the 12 as a safety
	Closed	Switch is attached when closed. This switch closed manual maintenance of the reader without the attached.
ALARM SET (optional)	---	Potentiometer driver adjustment. Turns the alarm ON or OFF and level at which sounds. If limit, it sounds measured ppm this value. high limit measured ppm value.

NOTE: See Figure 2-1 for locations.

SECTION 2.3, OPERATING PROCEDURES cont.

- r. After completion of use, check battery condition as described in para. g.
- s. Turn function switch to OFF position.
- t. When not operating, leave analyzer in assembled condition, and connected to battery charger.
- u. When transporting, disassemble probe and extension from readout assembly and return equipment to its stored condition.
- v. In case of emergency, turn function switch to OFF position.

2.4 BATTERY CHARGE

Check the battery charge as described in paragraph 2-3 g during each period of operation, at least once daily. If the battery is low as indicated by the meter reading or the warning indicator, it is necessary to recharge the battery.

To charge the battery, first insert the mini phone plug of the charger into the jack, J6, on the side of the bezel adjacent to the meter. Then insert the charger plug into a 120 or 230 V AC single phase, 50-60 cycle outlet. To ensure that the charger is functioning, turn the function switch, S1, to the battery check (BATT) position. The meter should deflect full scale if the charger is working and connections properly made. For normal battery charging, leave the function switch in the OFF position.

The analyzer can be operated, however, while recharging by turning the function switch to the desired position. Such usage will extend the time required to completely recharge the battery. The battery charger is not Div. II approved.

NOTE: On all Sira approved PI 101s it is necessary to connect the probe assembly before turning on the instrument and re-charging. Without following this procedure the instrument will not show battery check.

SECTION 3

CALIBRATION

INTRODUCTION

The PI 101 Analyzer is designed for trace gas analysis in ambient air and is calibrated at HNU with certified standards of benzene, vinyl chloride and isobutylene. Other optional calibrations are available (e.g., ammonia, ethylene oxide, H₂S, etc.). Calibration data is given in the data sheet. If a special calibration has been done, the data is given in the Application Data Sheet, which notes the sample source, type of calibration (see Section 8, Appendix), and other pertinent information.

Good instrumentation practice calls for calibration on the species to be measured in the concentration range to be used. This procedure assures the operator that the analyzer is operating properly and will generate reliable data.

Some general points to consider when calibrating the PI 101 are that the analyzer is designed for operation at ambient conditions and therefore the gas standards used for calibration should be delivered to the analyzer at ambient temperatures and pressure and at the proper flow rates.

WARNING:

The PI 101 is a non-destructive analyzer; calibrations using toxic or hazardous gases must be done in a hood.

The frequency of calibration should be dictated by the usage of the analyzer and the toxicity of the species measured. If the analyzer has been serviced or repaired, calibration should be done to verify operation and performance. It is recommended that calibration be checked frequently at first (daily or every other day) and then regularly based on the confidence level developed.

The normal meter scaleplate is 0 to 20. If the scaleplate is different, refer to the Application Data Sheet. If there are questions, consult the HNU representative before proceeding with calibration check.

An accurate and reliable method of calibration check is to use an analyzed gas cylinder in a test setup as shown in Figure 3-1 and described below. Additional material on calibration is given in Section 8, Appendix.

2 ANALYZED GAS CYLINDER

- a. Concentration - The calibration gas cylinder is to contain the species of interest made up in an air matrix at or near the concentration to be analyzed. If the component is unstable in air, another matrix is to be used. The final calibration mixture should be similar to the sample the PI 101 will analyze. If the expected concentration is not known then a concentration should be chosen that will cause a scale displacement of 50 to 80% on the X10 range. Calibration on X10 range will provide accurate values on the X1 range as well.

SECTION 3.2, ANALYZED GAS CYLINDER cont.

For use on the 0-2000 range, a two-standard calibration is preferred: one at 70 to 85% of the linear range and the other at 25 to 35% of the linear range. With the linear range of approximately 600 ppm for most compounds these points would lie between 420 to 510 ppm and 150 to 210 ppm, respectively.

- b. Stability - The calibration gas must be stable within the cylinder during the period of use. If the calibration is required in the field, then use of a small cylinder is recommended. In addition, the choice of cylinder material in contact with the gas must be considered (steel, aluminum or teflon). If there are any questions, the operator should request stability and usage information from the gas supplier.

WARNING

Extreme care must be taken in the handling of gas cylinders. Contents are under high pressure. In some cases, the contents may be hazardous. Many gas suppliers will provide data sheets for the mixtures upon request.

- c. Delivery - The cylinder containing the calibration mixture must be connected to a proper regulator.

WARNING

Never open the valve on a gas cylinder container without a regulator attached.

Leak test all tank/regulator connections as well as the main cylinder valve to prevent toxic or hazardous materials from leaking into the work area. Care must be taken that the materials of construction of the regulator will not interact with the calibration gas.

One method of sampling the calibration gas is illustrated in Figure 3-1. Connect the cylinder to one leg of the tee, a flow meter to the opposite leg, and the probe to the third leg. The flow meter does not require a valve. If there is a valve, it must be left wide open. The flowmeter is only to indicate excess flow. Adjust the flow from the regulator such that only a little excess flow is registered at the flowmeter.

SECTION 3.2, ANALYZED GAS CYLINDER cont.

This insures that the PI 101 sees the calibration gas at atmospheric pressure and ambient temperature.

- d. Usage - Generally, a gas cylinder should not be used below 200-300 psi as pressure effects could cause concentration variations. The cylinder should not be used past the recommended age of the contents as indicated by the manufacturer. In case of difficulty, verify the contents and concentration of the gas cylinder.
- e. Alternate means of calibration are possible. For more information, contact the HNU Service Department.

3.3 PROBE

- a. Identify the probe by the lamp label. If a question exists, disassemble the probe and inspect the lamp. The energy of the lamp is etched into the glass envelope.
- b. Connect the probe to the readout assembly, making sure the red interlock switch is depressed by the ring on the connector.
- c. Set the SPAN pot to the proper value for the probe being calibrated. Refer to the calibration memo accompanying the probe.
- d. Check the Ionization Potential (IP) of the calibration gas to be used. The IP of the calibration gas must be at or below the IP of the lamp.
- e. Proceed with the calibration as described in Section 3.4. Check the calibration memo for specific data. If any questions develop, call the HNU representative.
- f. NOTE: The 11.7eV lamp has a special cleaning compound. Do not use water or any other cleaning compound with the 11.7 eV lamp. Do not interchange ion chambers, amplifier boards or lamps between probes. (See Section 5.2).

.4 PROCEDURE

- a. Battery check - Turn the function switch to BATT. The needle should be in the green region. If not, recharge the battery.

SECTION 4

FUNCTIONAL DESCRIPTION

1 PRINCIPLE OF OPERATION

The analyzer measures the concentration of trace gases present in the atmosphere by photoionization. Photoionization occurs when an atom or molecule absorbs a photon of sufficient energy to release an electron and become a positive ion. This will occur when the ionization potential of the molecule in electron volts (eV) is less than the energy of the photon. The source of photons is an ultraviolet lamp with an energy of either 9.5, 10.2 or 11.7 eV.

The detection process is shown in Figure 4-1. Sample gases enter through the inlet into the ion chamber and are exposed to photons emanating from the ultraviolet lamp. Ionization occurs for those molecules having ionization potentials near to or less than that of the lamp.

A positive-biased polarizing electrode causes these positive ions to travel to a collector electrode in the chamber. Thus the ions create an electrical current which is amplified and displayed on the meter.

This is proportional to the concentration of trace gas present in the ion chamber and to the sensitivity of that gas to photoionization.

In service, the analyzer is first calibrated with a gas of known composition equal, close to or representative of that to be measured.

2 IONIZATION POTENTIALS

Gases with ionization potentials near to or less than that of the lamp will be ionized. These gases will thus be detected and measured by the analyzer.

Gases with ionization potentials higher than that of the lamp will not be detected.

Ionization potentials for various atoms, molecules and compounds are given in Tables 8-1 thru 8-13 in Section 8, Appendix.

The ionization potential of the major components of air, i.e., oxygen, nitrogen, and carbon dioxide, range from about 12.0 eV to about 15.6 eV and are not ionized by any of the three lamps.

Gases with ionization potentials near to or slightly higher than the lamp are partially ionized, with low sensitivity.

IONIZATION SENSITIVITY

The amount of ionization of a species of gas exposed to photons, its sensitivity, is a characteristic of that particular species. This is illustrated in Table 4-1 for a number of chemical groupings and in Table 8-14 for a large number of individual species when exposed to photons from a 10.2 eV lamp.

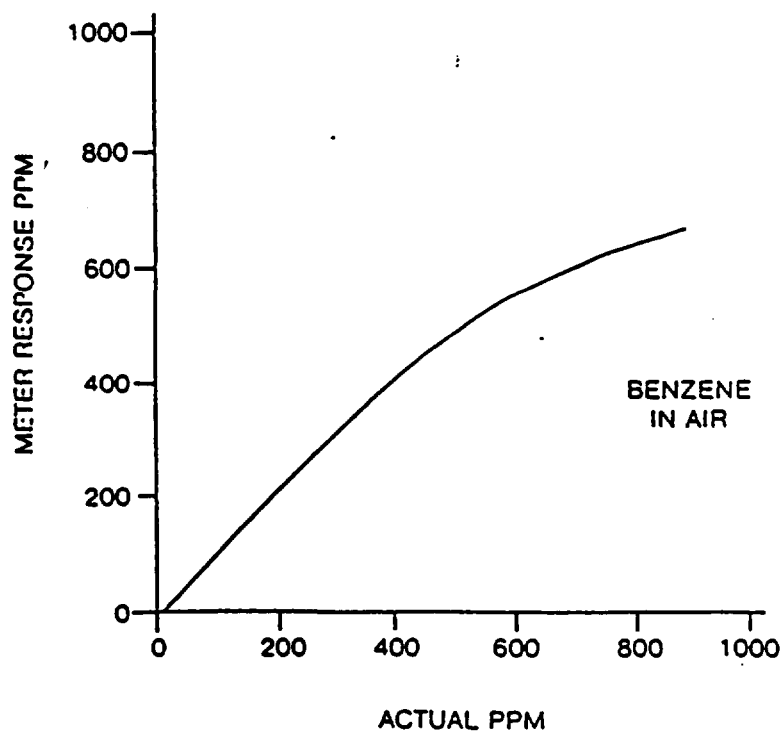
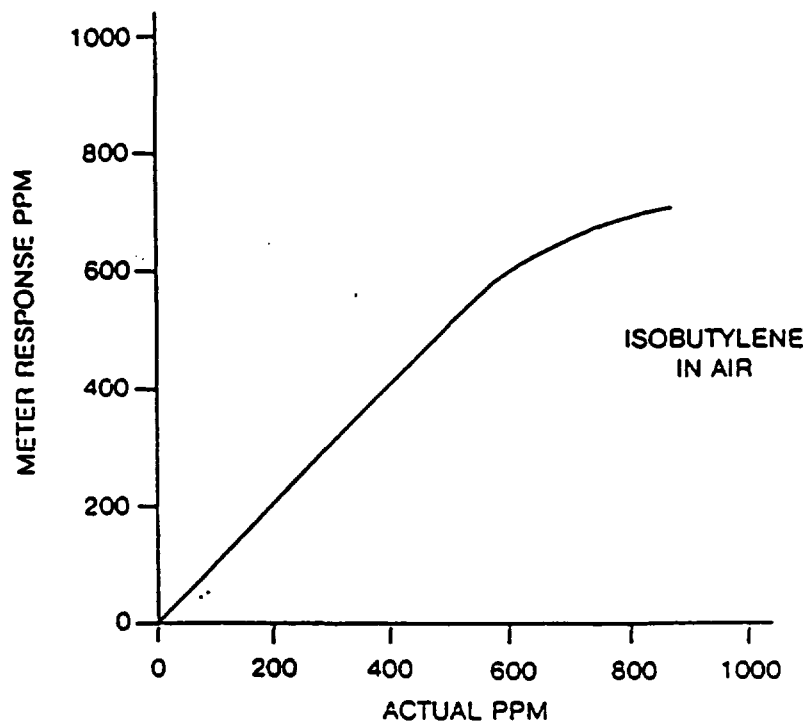


FIGURE 3-2
TYPICAL CALIBRATION CURVES (10.2 eV)

Section 4.3, SENSITIVITY cont.

The species with the higher values are more sensitive to the 10.2 eV photons than are those with lower values. For example, referring to data in Table 8-14, an analyzer calibrated for benzene, when measuring a sample containing 10 ppm of benzene, will read 10.0 and when measuring a sample containing 10 ppm of vinyl chloride will read 5.0. This shows the lower sensitivity of the vinyl chloride. Similar conditions are the case for the 9.5 and 11.7 eV lamps.

4.4 CALIBRATED PROBES AND SELECTIVITY

The standard probe provided with the analyzer contains a 10.2 eV lamp. Optional probes containing lamps of 9.5 and 11.7 eV permit selective determination or exclusion of species.

The probe with the 9.5 eV lamp permits measurement of species having IP values lower than 9.5 eV in the presence of interfering species with IP values above 9.5 eV.

The probe with the 11.7 eV lamp permits measurement of species with IP values above 10.2 up to approximately 11.7 eV.

The probes with different lamps are interchangeable in use within individual readout assemblies for different applications. The amplifier and ion chamber in the probe are selected for the specific eV lamp. Lamps of different eV ratings cannot be interchanged between probes. Examples of selective application of these probes is given in Table 4-2. Additional applications of the use of the probes are described in the sections that follow and illustrated in Figure 4-2. Further examples are given (without discussion) in Table 4-3. Re-zeroing is performed after each probe interchange.

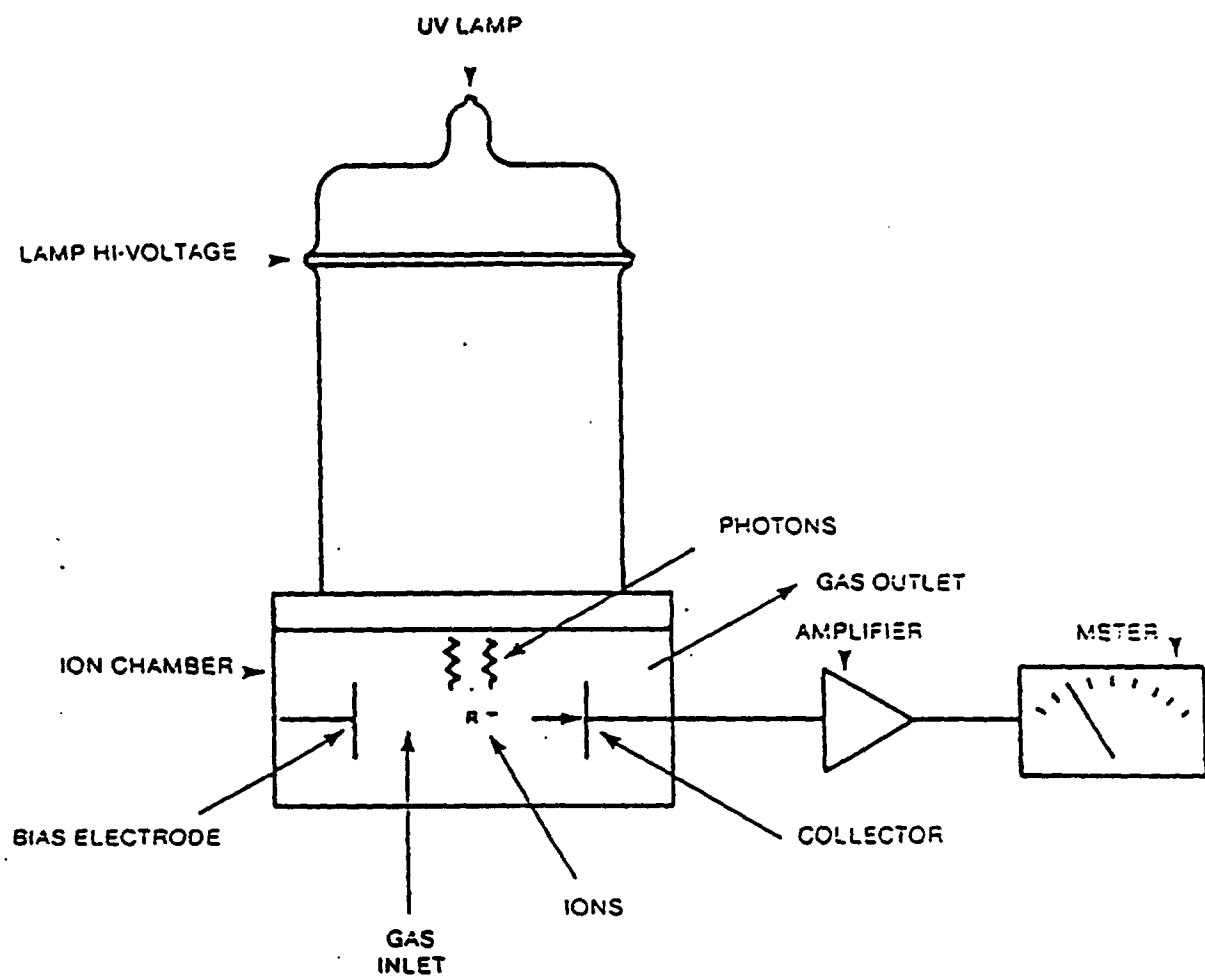
4.5 10.2 eV PROBE

The 10.2 eV probe is the standard probe used with the Trace Gas Analyzer. The approximate span settings for a 10.2 eV probe that would give direct readings of the amounts of trace gas of a particular species in a sample is given in Table 8-14. For example, when the span control is set at 4.3 the analyzer will read 10 ppm when measuring a sample containing 10 ppm of vinyl chloride. These span settings will vary with the condition of the lamp. Application of the 10.2 eV probe is illustrated in examples "a", "b", and "c" in Figure 4-2. In each case the trace gas (or gases) is contained in a standard atmosphere.

Example "a" shows the use of the 10.2 eV probe to measure Vinyl Chloride (IP=9.995) by itself.

Example "b" shows the use of the 10.2 eV probe to measure Vinyl Chloride (IP=9.995) in the presence of a second gas, Acetylene (IP=11.4). The acetylene is not ionized and the probe gives a direct reading of the Vinyl Chloride above.

Example "c" shows the use of the 10.2 eV probe to measure Isoprene (IP=9.08) by itself. A 9.5 eV probe may also be used but is less sensitive. the 10.2 eV probe is recommended.



**FIGURE 4-1
DETECTION PROCESS**

TABLE 4-2

TYPICAL APPLICATIONS OF INTERCHANGEABLE PROBES

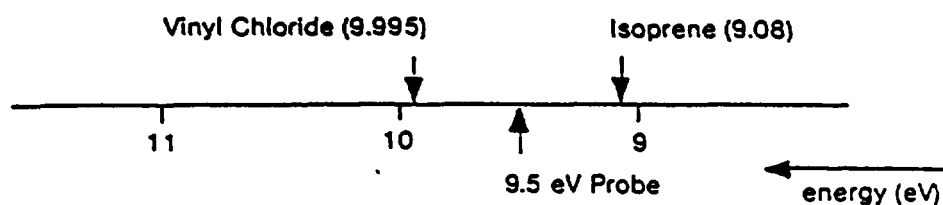
Compound	Ionization potentials (eV)	Relative Sensitivity	
		9.5/10.2 eV	11.7/10.2 eV
p-Xylene	8.44	0.10	0.104
p-Chlorotoluene	8.70	0.09	0.112
Toluene	8.82	0.09	0.112
o-Chlorotoluene	8.83	0.075	0.112
Ethyl Acetate	9.19	0.075	0.112
Benzene	9.24	0.10	0.10
Methyl Mercaptan	9.24	0.10	0.072
Pyridine	9.32	0.075	0.122
Allyl Alcohol	9.67	0.10	0.112
Crotonaldehyde	9.88	0.075	0.104
Amyl Alcohol	9.80	0.09	0.116
Cyclohexane	9.88	0.075	0.104
Vinyl Chloride	9.95	0.085	0.112
Butanol	10.94	0.09	0.176
Ammonia	10.15	0.06	0.160
Acetic Acid	10.37	0.04	0.560
Ethylene	10.52	0.0	0.320
Ethylene Oxide	10.56	0.0	0.298

$$\text{Relative sensitivity} = \frac{\text{Response with 9.5 or 11.7 eV probe}}{\text{Response with 10.2 eV probe}}$$

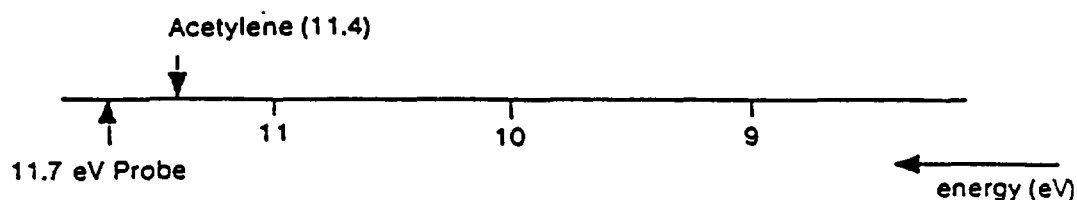
TABLE 4-1
RELATIVE PHOTOIONIZATION SENSITIVITIES FOR GASES

Chemical Grouping	Relative Sensitivity (see NOTE)	Examples
Aromatic	10	Benzene, Toluene, Styrene
Aliphatic Amine	10	Diethylamine
Chlorinated Unsaturated	5-9	Vinyl Chloride, Vinylidene Chloride, Trichloroethylene
Carbonyl	7-9	MEK, MiBK, Acetone, Cyclohexanone
Unsaturated	3-5	Arolein, Propylene, Cyclohexanone, Allyl Alcohol
Sulfide	3-5	Hydrogen Sulfide, Methyl Mercaptan
Paraffin (C5-C7)	1-3	Pentane, Hexane, Heptane
Ammonia	0.3	
Paraffin (C1-C4)	0	Methane, Ethane

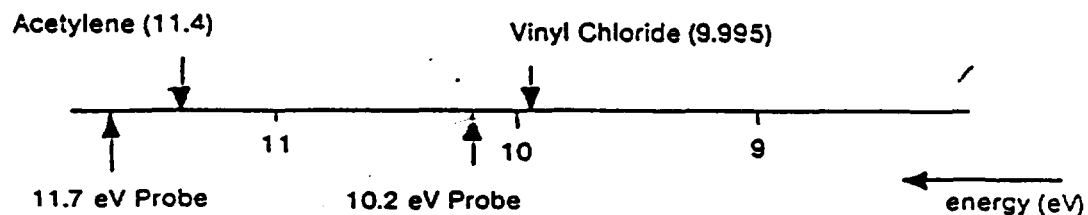
NOTE: Relative sensitivity = meter reading when measuring 10 ppm of the listed gas with instrument with 10.2 eV probe calibrated for 10 ppm of benzene, span pot setting = 9.8 for direct reading of benzene.



- d. 9.5 eV Probe measures Isoprene (IP = 9.08)
but not Vinyl Chloride (IP = 9.995)



- e. 11.7 eV Probe measures Acetylene (IP = 11.4)



- f. 11.7 eV Probe measures both Acetylene (IP = 11.4)
and Vinyl Chloride (IP = 9.995)

10.2 eV Probe measures Vinyl Chloride
but not Acetylene

Difference between the two readings is the
measure of Acetylene

FIGURE 4-2
APPLICATION OF PROBES CONTINUED

TABLE 4-3
PROBE APPLICATION EXAMPLES

Application	Recommended
Styrene (IP = 8.47) Alone	10.2
Hexane (IP = 10.48) Alone	10.2
Formaldehyde (IP = 10.87) Alone	11.7
Styrene/Hexane Together	10.2 and 9.5 Use 10.2 to measure 9.5 to measure difference will concentration
Formaldehyde/Styrene Together	10.2 and 11.7 Use 11.7 to measure 10.2 to measure difference will concentration

SECTION 4 cont.

4.6 9.5 eV PROBE

The 9.5 eV probe is used to measure gases with $IP < 9.5$ when it is necessary to exclude gases that may be present having $IP > 9.5$ eV and < 10.2 eV. This is illustrated by example "d" in Figure 4-2. Here a 9.5 eV probe is used to measure Isoprene ($IP = 9.08$) in the presence of Vinyl Chloride ($IP = 9.995$).

Gain settings for a 9.5 eV probe to give direct readings for various species are given in Table 8-15.

4.7 11.7 eV PROBE

The 11.7 eV Probe is used to measure trace gases with $IP > 10.2$ eV but less than 11.7 eV. The use of this probe by itself is illustrated in example "e". Here the 11.7 eV probe is used to measure Acetylene ($IP = 11.4$ eV). The use of this probe in conjunction with a 10.7 eV probe is illustrated in example "f". In this case, two gases are present, Acetylene ($IP = 11.4$) and Vinyl Chloride ($IP = 9.995$). The objective is to obtain a measurement of the Acetylene alone.

The 11.7 eV probe measures the total presence of both Acetylene and Vinyl Chloride together. The 10.2 eV probe measures just the Vinyl Chloride, excluding the Acetylene. The difference between the two readings is the measure of the Acetylene.

Gain settings for the 11.7 eV probe to give direct readings for various species are given in Table 8-15.

4.8 EQUIPMENT DESCRIPTION

The components of the analyzer are located in the probe and the readout assembly (see Figures 4-3 and 4-4). The ion chamber, UV light source, amplifier board, and fan are located in the probe assembly. The battery, the power supply board, and the meter are located in the readout assembly. The probe and the readout assembly are connected by an 800 cm (32") cable.

The fan draws gas in through the probe and ion chamber. The flow rate is approximately 100 cubic centimeters per minute.

Small variations in the flow rate do not affect the measurement. A major obstruction to the flow, however, will prevent proper operation and lengthen response time. The fan cannot draw a sample from any distance or across a pressure drop.

The output from the ion chamber is amplified and read out on the meter.

Voltage for the light source, ion chamber, amplifier and fan is provided from a DC converter on the power supply board. The battery provides the source of power for the converter. The positive side of the battery is grounded.

Section 4.8, EQUIPMENT DESCRIPTION cont.

The input signal from the ion chamber enters at connector P1/J1 (see schematic Figure 4-5), goes to transistor Q1 and amplifier A1. The zero adjustment setting on the control panel enters thru pins 3 and C on P2/J2, thence to the transistor Q1.

Power for the amplifier enters on pins D and F respectively. Span control adjustment from the control panel enters at pin B, signal output at pin E, and ground connector at pin J.

The output signal from the amplifier goes thru pin E in the cable connector P3/J3 to pad 11 on the power supply board, to the resistor network R39 thru R49, including the adjustable pot R48. From there it goes to the meter through the function switch on the control panel.

Connections from the resistor network through the function switch serve to set the operating range of the meter. Input to the span control potentiometer comes from this same network through the function switch. The output of the span control pot provides feedback control to the amplifier through pin H on the cable, pin B on the amplifier board, and feedback resistor R5 to the amplifier input.

Power for the UV lamp, D1, is provided by rectifier networks containing CR4-9 operating from the red and white terminals of transformer T1. Voltage for the lamp (pad 22 on the power supply board or J3 pin D, Figure 4-6) will be as follows for the several different conditions that may exist.

Condition	Voltage, V DC
Probe connected, lamp operating properly	-350 to -450
Probe connected, lamp not operating properly	-1100 to -1200
Probe not connected, high voltage switch not depressed	0 to -300
Probe not connected, high voltage switch depressed manually	-1100 to -1200

Power for the ion chamber is provided by rectifier network CR2 and 3 operating from terminals 6 and 7 of T1 and voltage regulator Z1. Power for the amplifier is provided by rectifier networks CR13-16 operating from terminals 4, 5 and 8 of T1. Power for the fan motor is provided by rectifier network CR18-21 operating from terminals 1, 2 and 3 of transformer T1. Conversion of the DC from the battery for input power to T1 is accomplished by Z2. Power for a recorder is available at connector J7.

Section 4.8, EQUIPMENT DESCRIPTION cont.

D3 provides indication if the battery voltage falls below the prescribed level of 11.23 V DC. J6 provides for connection of the battery charger. The six bank switch, S1, is the function switch. Microswitch S2 disables the high voltage power to the cable connector when disconnected.

The alarm board (optional) is connected to the power supply board by the cable containing connector P6/J6. The amplifier output signal, pin 9 on P6/J6 (see schematic Figure 4-6), goes to one input of amplifier U1 (see schematic Figure 4-5).

The output from the alarm set control on the front panel, pin 4 on P6/J6, goes to the second input of U1. The output from U1 operates the audible alarm through Q3 or Q2. Only one of these is connected at the factory to give low alarm or high alarm, respectively, as requested by the user. The alarm will operate when the signal falls or rises above this threshold. Reference power for the alarm setting enters the board at pin 2 and power for the amplifier and transistors Q1 thru Q3 enters at pin 5. The battery charger provides 15.0 V DC for recharging.

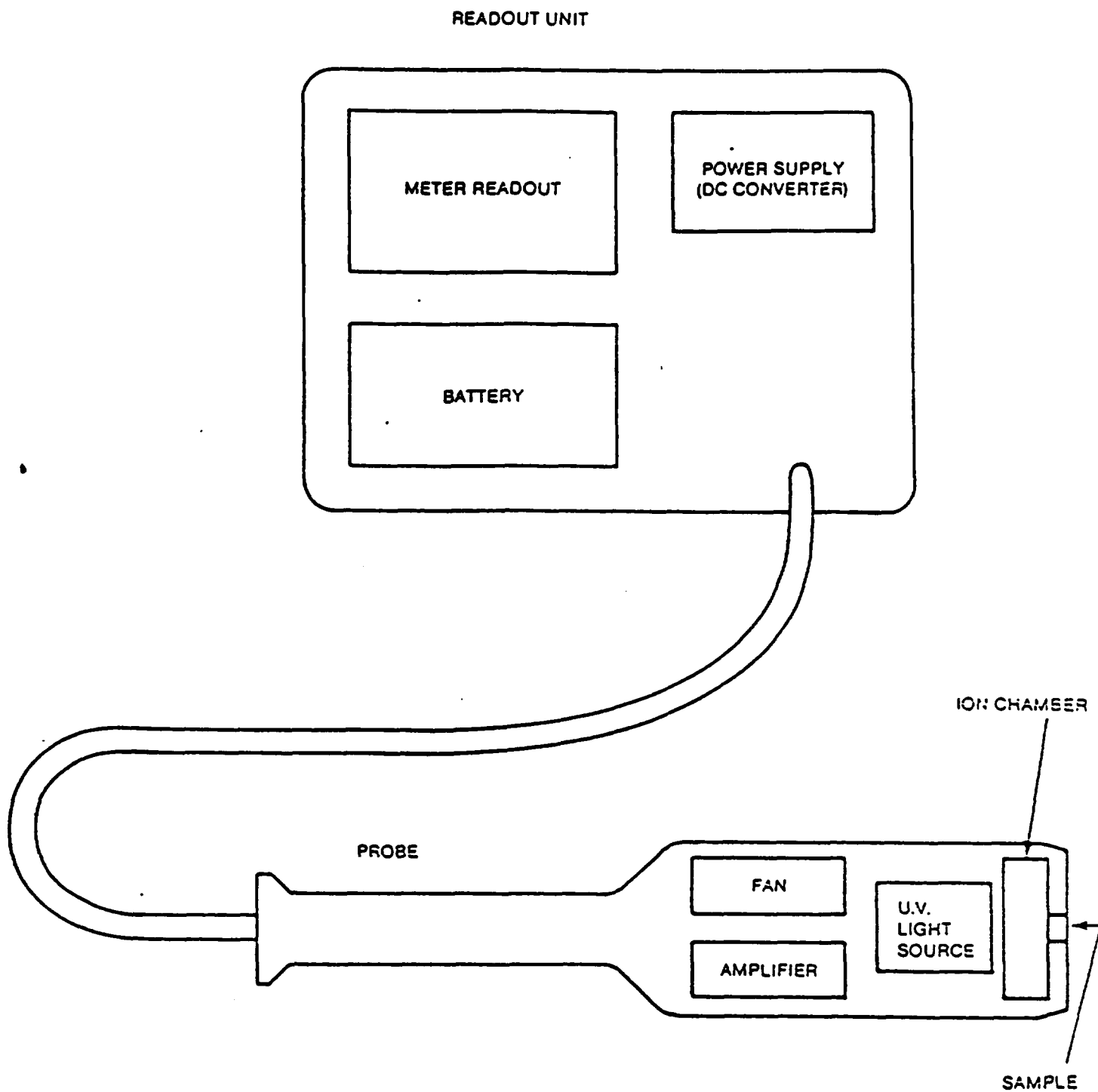
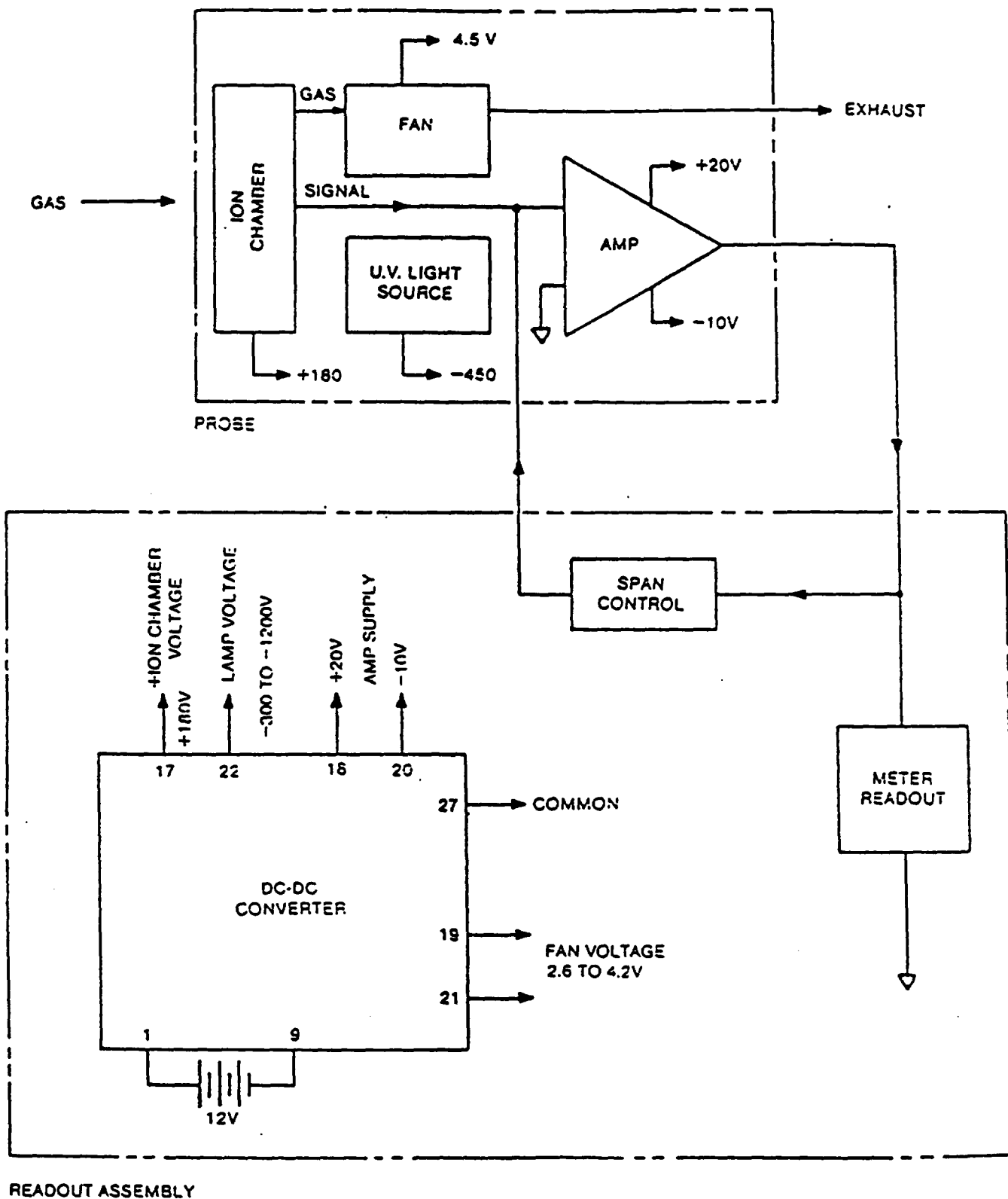


FIGURE 4-3
BLOCK DIAGRAM
COMPONENT LOCATION



NOTE: ALL VOLTAGES SHOWN ARE NOMINAL VALUES.

FIGURE 4-4

SECTION 5

MAINTENANCE

5.1 INTRODUCTION

Maintenance of the analyzer consists of cleaning the lamp and ion chamber, replacement of the lamp or other component parts or subassemblies.

WARNING: Turn the function switch on the control panel to the OFF position before any disassembly. Otherwise, high voltage of 1200 V DC will be present.

WARNING: Use great care when operating the analyzer with the readout assembly outside its case due to the presence of 1200 V DC.

WARNING: Do not look at the light source from any closer than 6 inches with unprotected eyes. Observe only briefly. Continued exposure to ultraviolet energy generated by the light source can be harmful to eyesight.

CAUTION: Do not interchange lamps of different eV ratings in a probe. Amplifier and components are selected for a specific eV lamp. A probe with the wrong lamp will not operate properly.

5.2 UV LAMP AND ION CHAMBER CLEANING

During periods of operation of the analyzer, dust or other foreign matter could be drawn into the probe forming deposits on the surface of the UV lamp or in the ion chamber. This condition is indicated by meter readings that are low, erratic, unstable, non-repeatable, or drifting, or show apparent moisture sensitivity. These deposits interfere with the ionization process and cause erroneous readings. Check for this condition monthly or as required. Cleaning can be accomplished as follows:

- a. Disassemble the probe and remove the lamp and ion chamber (see Section 5.5). Exercise great care in doing so to prevent inadvertent damage to these components.
- b. First check the lamp window for fouling by looking at the surface at an incident angle. Any deposits, films or discoloration may interfere with the ionization process. Clean the window as follows:

1) 9.5 and 10.2 eV lamps

- a) First clean by rubbing gently with lens tissue dipped in a detergent solution.
- b) If this does not remove deposit, apply a small amount of HNU cleaning compound (PA101534) directly onto the lens of the lamp and spread evenly over surface with a non-abrasive tissue (e.g. Kim-Wipe) or a lens tissue.
- c) Wipe off compound with a new tissue.
- d) Rinse with warm water (about 80 degrees F) or damp tissue to remove all traces of grit or oils and any static charge that may have built up on the lens. Dry with new tissue.
- e) Reinstall lamp in detector and check analyzer operation.
- f) If performance is still not satisfactory replace the lamp. See Section 5.3 and Section 6.

2) 11.7 eV lamp

- a) Clean by putting a freon or chlorinated organic solvent on a tissue and rubbing gently.
 - b) DO NOT CLEAN THIS LAMP WITH WATER OR ANY WATER MISCIBLE SOLVENTS (methanol or acetone). It will damage the lamp.
 - c) DO NOT USE THE CLEANING COMPOUND used for the 9.5 and 10.2 eV lamps under any circumstances on the 11.7 eV lamp.
- c. Then inspect the ion chamber for dust or particulate deposits. If such matter is present, the chamber can be cleaned by removing the outer Teflon ring, and the four screws holding the retaining ring. Carefully move the retaining ring aside (NOTE: this is soldered) and remove the screen. A tissue or cotton swab, dry or wetted with methanol, can be used to clean off any stubborn deposits. The assembly can also be gently swirled in methanol and dried gently at 50-60 degrees C for approximately a half hour. No liquid must be present at reassembly as this would affect the performance. Do not clean the ion chamber with the HNU cleaning compound cited above in para. b.1)b).
- d. Reassemble the probe and check analyzer operation.
 - e. If performance is still not satisfactory replace the lamp. See Section 5.3.

5.3 LAMP REPLACEMENT

To replace the lamp, disassemble the probe, remove the old lamp, install a new one of the same eV rating and reassemble.

WARNING

Turn the function switch on the control panel to the OFF position before disassembly. Otherwise, high voltage of 1200 V DC will be present.

CAUTION

Do not exchange lamps of different eV ratings in a probe. Amplifier and components are selected for a specific eV lamp. A probe with the wrong lamp will not operate properly.

Set the SPAN pot to 9.8 for the 10.2 eV lamp. Remove the readout assembly case (see Section 5.6). Locate the gain control potentiometer, R48, on the power supply board as shown on Figure 6-1. Recalibrate the analyzer adjusting this potentiometer, R48, with a small screwdriver to obtain the specified ppm reading, leaving the SPAN pot set at 9.8.

For the 9.5 and 11.7 eV lamps see the Application Data Sheet or calibrations memo for the proper span pot settings and readings.

WARNING

Use great care when operating the analyzer with the readout assembly outside its case due to the presence of 1200 V DC.

When calibration is accomplished, turn the analyzer OFF and replace the readout assembly in its case.

Adjustment of R48 potentiometer is used only when a new lamp is installed. At all other times adjustment is accomplished using the SPAN control potentiometer.

If calibration cannot be achieved, see Section 6, Troubleshooting.

SECTION 5 cont.

5.4 LAMP SIZE CHANGE

If different applications for the analyzer would require different size lamps, separate probes, each with its own eV lamp, must be used. A single readout assembly will serve for any of the probes. A change in probe will require resetting of the zero control and the span pot. Calibration should be checked to verify proper operation.

5.5 PROBE DISASSEMBLY/ASSEMBLY

WARNING

Turn the function switch on the control panel to the off position before disassembly. Otherwise high voltage of 1200 V DC will be present.

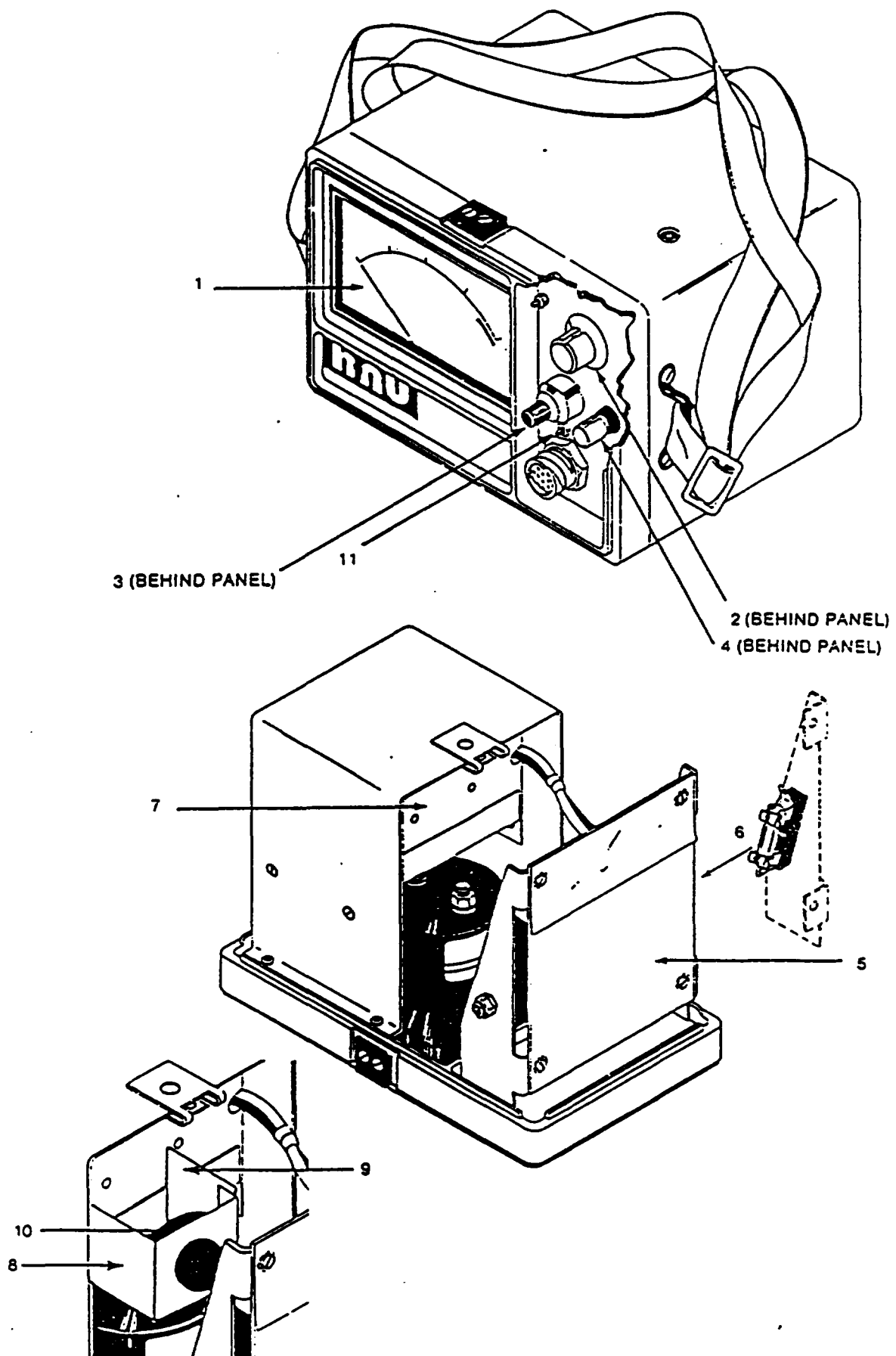


FIGURE 7-2
PARTS LOCATION READOUT ASSEMBLY

TROUBLESHOOTING DATA

Symptom	Probable Cause	Corrective Action
1. Meter indicates low battery	a. Blown fuse (Fuse F1, 2A, 5-3)	1) Check fuse. If blown, check for evidence of shorts in wiring, then replace fuse.
	b. Bad connections	1) Check wiring connections. Resolder poor or bad connections.
	c. Broken meter movement	1) Tip instrument rapidly from side to side. Meter needle should move freely, and return to zero. If faulty, replace with new meter.
	d. Battery dead	1) Disconnect battery and check with volt-ohmmeter. Replace if dead.
	e. Battery charge low	1) Recharge battery, check meter with function switch in BATT position to ensure the charger is operating properly (see Table 2-1, BATT)
2. Low battery	a. Power supply defective	1) Check power supply voltages (see Table 6-2 and Figure 6-1). If in error, replace power supply assembly.
3. UV lamp not ON	a. High Voltage interlock (Micro-switch S2) at probe cable connector on readout assembly not operating	1) Check by applying pressure to switch plunger with cable in place. Adjust the screw on side of cable connector, if required, to increase throw of switch plunger.
	b. High voltage supply out or faulty	1) Check high voltage output on power supply board (pad 22). If voltage not correct, (see Table 6-2) replace power supply board.

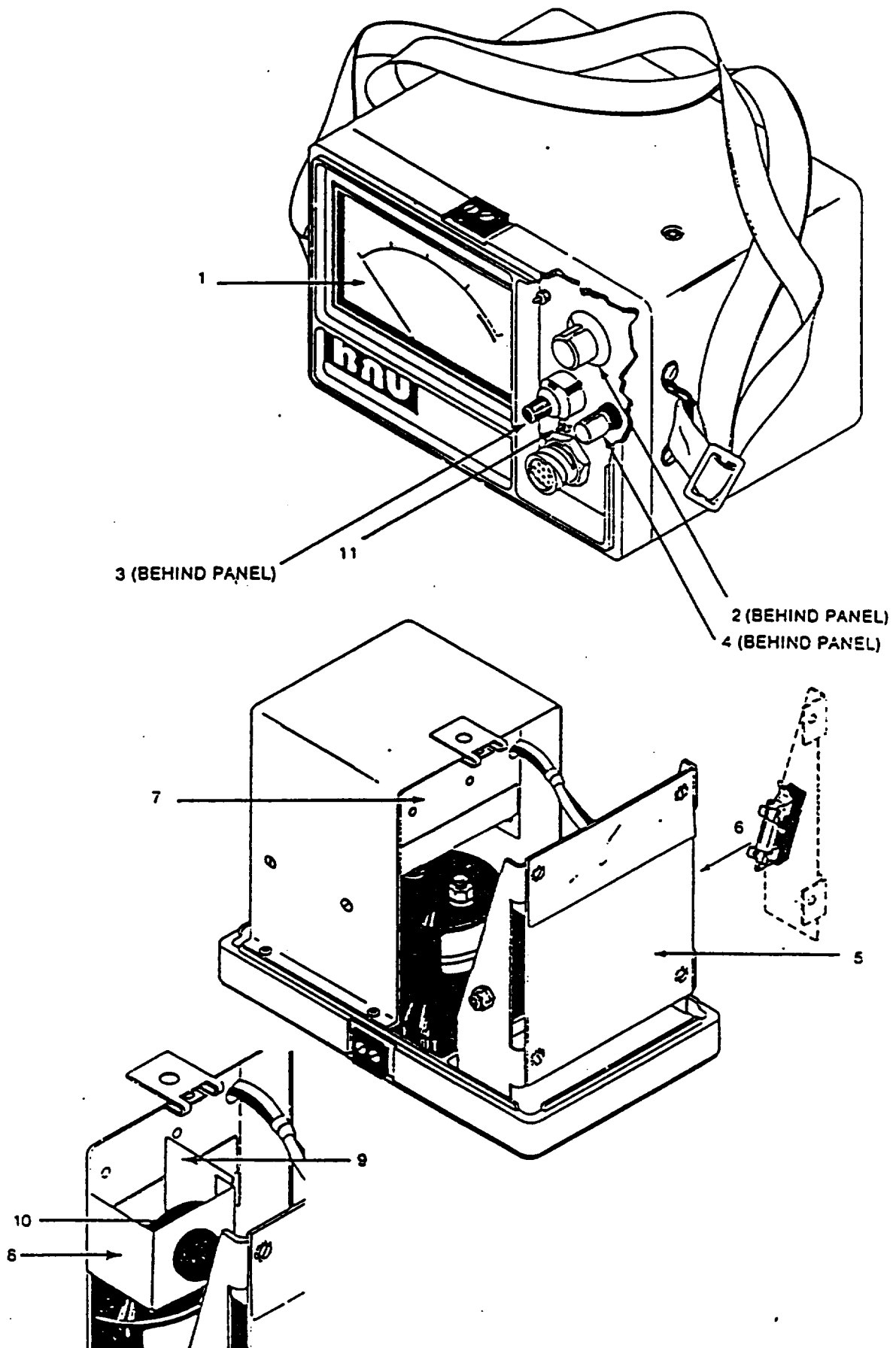


FIGURE 7-2
PARTS LOCATION, READOUT ASSEMBLY

6. Meter does not return to zero in STANDBY

- a. Broken meter movement 1) See 1-c-1 above.
- b. Dirty or open connections to meter 1) See 5-c-1 above.
- c. Dirty or open connections in probe 1) See 5-a-1 above.
- d. Zero adjust faulty 1) Rotate zero adjust pot (see Fig. 2-1) (R50, Fig. 4.6). Check pot output at meter probe connector (J3 pins B and L). If voltage does not vary, replace zero adjust pot.
- e. Amplifier faulty 1) Rotate zero adjust pot. Check amplifier output at probe connector (J3 pin H) or observe meter. If voltage level on meter does not respond, replace amplifier board
- f. Ion chamber shorted 1) Clean ion chamber. (see Section 5.2). Recheck for return to zero in STANDBY.

2) Replace ion chamber.

7. Meter readings, high or low

- a. Incorrect calibration 1) Recalibrate (see Section 3).
- b. Lamp dirty 1) Clean lamp (see Section 5.2)
- c. Contamination in ion chamber. 1) Clean ion chamber. (see Section 5.2)
- d. Power supply board faulty 1) Check power supply board outputs (pads 17, 20 and 22 (Table 6-2). If voltages not correct, replace power supply board.
- e. Dirty or loose connections 1) Clean or tighten connections at amplifier board, probe cable, and meter.

SECTION C

APPENDIX

This section contains the following additional information pertinent to the PI 101 Analyzer.

Section	Subject
C.1	Static Calibration
C.2	Calibration Checking with Isobutylene
C.3	Calibration with Alternate Gas
C.4	Uncalibrated Operation
C.5	Ionization Tables
C.6	Warranty
C.7	Publications List

TABLE 6-3
PIN DATA, AMPLIFIER PCB, P2/J2

Pin #	Signal Name	Voltage (V DC)
A	Ground	0
B	Span Control Setting	varying
C	Zero Adjust	varying
D	Amplifier Power	-9.5 to -10.5
E	Amplifier Signal	0 to -5.0
F	Zero Adjust Voltage	+18 to +21
3	Zero Adjust Voltage	varying

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APPENDIX

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TABLE 6-5

PIN DATA, ALARM CABLE P6/J6

Pin #	Signal Name	Voltage (V DC)
1	Alarm set pot, high end	+5.1
2	Alarm set power	+7
3	Alarm power	0 or -11 to -15
4	Alarm set	+0.02 to +5.1
5	Alarm board power	+10
6	Amplifier power	-9.5 to -10.5
7	Alarm set pot, low end	+0.023
8	Ground	0
9	Amplifier signal	0 to -5.0

SECTION 2.1, STATIC CALIBRATION cont.

- g. Allow the analyzer to sample from the container. Compression of the container by hand may be necessary since the analyzer will not sample across a pressure drop. The analyzer flow is about 100 - 200 cc/min and small changes will not effect the reading. However, the flow should be constant.
- h. Observe the readings during calibration to ensure that the gas is well mixed and there are no concentration gradients within the container. This will be evident by uniform meter readings.
- i. Record the reading after about 10 seconds. The reading should be stable for up to 2 minutes since the flow rate is 100 to 200 cc/min. Large fluctuations in flow could effect the readings.
- j. Adjust the SPAN control to set the analyzer to be direct reading at a concentration level near the range to be used.
- k. Prepare 5 or 6 different concentrations of the calibration gas and plot the instrument readings versus concentration in ppm (v/v) to obtain a calibration curve. Clean the container between each point. For spot checking the calibration, two levels close to the measured concentration which agree to within 10% are acceptable. Concentrations lower than 100 ppm of a gas can be prepared by diluting a 100 or 200 ppm level with clean air. However, do not dilute a mixture by more than a factor of 10. A bias in the calibration curve could indicate preparation/container effects, such as "hang-up" on the walls of the container at high levels resulting in lower readings. At low levels, the compound may diffuse out or evaporate off the walls resulting in higher readings. Gentle heating should alleviate this condition.

REPLACEMENT PARTS LIST

MODEL PI101
(see Fig. 7-3)
1 2 3 4 5

Part No. -----	Refer to Fig. No. -----	Assembly -----
00017-1	1	Strap, neck
00018-1	2	Strap, waist
00013-A1	3	Charger, battery: 15.0 VDC, 120 V AC, 1 pH input
00044-1	4	Case, cover
00050	5	Case, readout assembly

SECTION 8.1, STATIC CALIBRATION cont.

- g. Allow the analyzer to sample from the container. Compression of the container by hand may be necessary since the analyzer will not sample across a pressure drop. The analyzer flow is about 100 - 200 cc/min and small changes will not effect the reading. However, the flow should be constant.
- h. Observe the readings during calibration to ensure that the gas is well mixed and there are no concentration gradients within the container. This will be evident by uniform meter readings.
- i. Record the reading after about 10 seconds. The reading should be stable for up to 2 minutes since the flow rate is 100 to 200 cc/min. Large fluctuations in flow could effect the readings.
- j. Adjust the SPAN control to set the analyzer to be direct reading at a concentration level near the range to be used.
- k. Prepare 5 or 6 different concentrations of the calibration gas and plot the instrument readings versus concentration in ppm (v/v) to obtain a calibration curve. Clean the container between each point. For spot checking the calibration, two levels close to the measured concentration which agree to within 1% are acceptable. Concentrations lower than 100 ppm of a gas can be prepared by diluting a 100 or 200 ppm level with clean air. However, do not dilute a mixture by more than a factor of 10. A bias in the calibration curve could indicate preparation/container effects, such as "hang-up" on the walls of the container at high levels resulting in lower readings. At low levels, the compound may diffuse out or evaporate off the walls resulting in higher readings. Gentle heating should alleviate this condition.

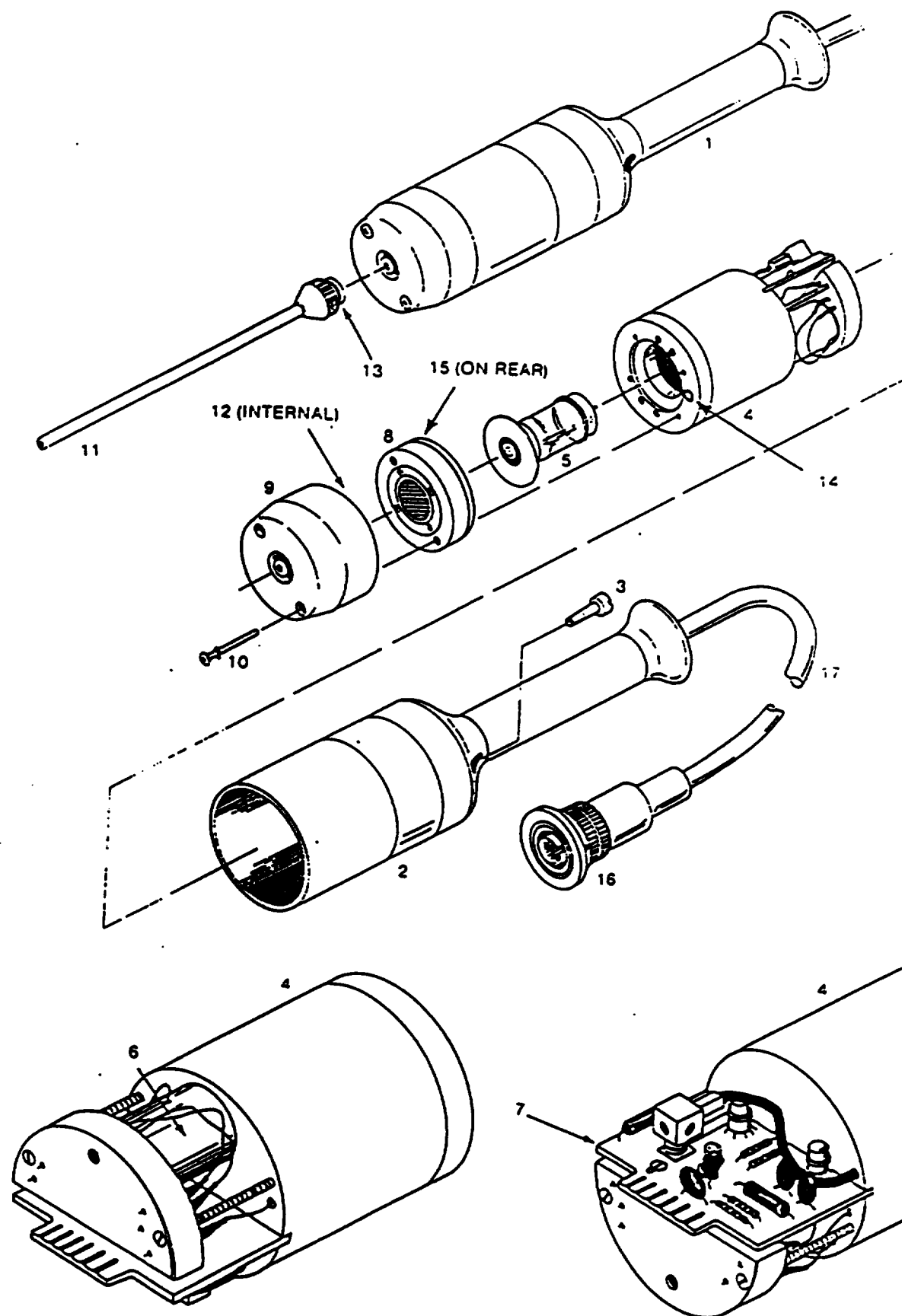


FIGURE 7-1
PARTS LOCATION, PROBE ASSEMBLY

SECTION 8 cont.

2 CALIBRATION CHECKING WITH ISOBUTYLENE

The calibration of the analyzer can be rapidly checked by the use of an HNU small disposable cylinder containing isobutylene (HNU pn 101-350) with a regulator (HNU pn 101-351).

At the factory, the analyzer is first calibrated on the desired gas standard at the specified concentration. Then a measurement is made with isobutylene.

The ppm reading along with the span setting using isobutylene is recorded in the calibration report.

In service, the analyzer calibration can be checked and readjusted if necessary by using this cylinder and regulator as follows:

- a. Connect the analyzer to the regulator and cylinder with a short piece (butt connection) of tubing as shown in Figure 8-1. The calibration gas in the cylinder consists of a mixture of isobutylene and zero air. Isobutylene is nontoxic and safe to use in confined areas. There are no listed exposure levels at any concentration.
The regulator sets and controls the flow rate of gas at a value preset at the factory. This will be about 250 cc/min..
It is important that the tubing be clean since contaminated tubing will effect the calibration reading. Do not use the cylinder below about 30 psig as readings below that level can deviate up to 10% from the rated value.
Safely discard the disposable cylinder when empty. Do not refill this cylinder.
It is against the law to transport refilled cylinders.
- b. With the SPAN setting and the function switch at the same positions as listed in the Application Data Sheet or Calibration Report, open the valve on the cylinder until a steady reading is obtained.
- c. If the reading is the same as the recorded data, the analyzer calibration for the original species of interest is still correct.
- d. If the reading has changed, adjust the SPAN setting until the reading is the same.
- e. Shut off the cylinder as soon as the reading is established.
- f. Record and maintain this new SPAN setting. Then recalibrate the analyzer on the species of interest as soon as possible.
- g. Whenever the analyzer is recalibrated, it is to be immediately checked with the small cylinder and the reading recorded. This can then be used for later checking in the field.

3.1 STATIC CALIBRATION

A technique known as static calibration is very useful when it is desired to calibrate with a particular special mixture rather than an available standard. The procedure is:

- a. Select an inert container of known volume, e.g., a 4 liter Teflon bag, and clean by filling with hydrocarbon-free air and exhausting three or four times. The container and fittings should have minimal interaction with the gas to be used.
 - b. Fill the container with hydrocarbon-free air between samples and test with the analyzer. Repeat several times to determine the background level in the container. Correct instrument response by subtracting this background for accurate results.
 - c. Fill a small, inert gas-tight syringe (glass/Teflon) (e.g., 1 cc) with the desired gas and inject into the container. See the sample calculations. If the desired material is a liquid at room temperature, a smaller syringe (e.g., 1 ul or 10 ul) is used. Inject a known volume of the liquid into the container. Touch the syringe tip to the inside of the container to remove any residue droplets. A needle on the syringe is not necessary, but if one is used, it should be used throughout or delivery errors are possible.
 - d. Fill the container with a known volume of clean air and stopper the container. A large syringe, such as the Hamilton Model S1500 (1.5 liters) is recommended. Calibrated flowmeters may also be used. The accuracy of this calibration method is directly dependent on the accuracy used to measure the species involved.
 - e. Wait several minutes until the gas is well mixed or the liquid is evaporated and mixed. Check for liquid in the container before proceeding. If the liquid does not completely evaporate, the correct concentrations will not be seen in the gas phase. Warning the bag may be necessary to ensure complete evaporation.
 - f. Connect the probe inlet to the container making sure there are no leaks.
- CAUTION: Work in a hood if hazardous gases are used.

----- WARNING -----

Be very careful to note the toxic levels and the Lower Explosive Limits for personal safety. The PI 101 is a nondestructive analyzer and must be used in a hood when calibrating with toxic or hazardous materials.

SECTION 8 cont.

8.3 CALIBRATION WITH ALTERNATE GAS

If a calibration standard with the same trace gas as that to be measured is not available or is hazardous, it is possible to use an alternate calibration gas. (Note : This technique may not be as accurate as calibration with the species of interest.)

In this case, the expected reading for calibration must be compensated for the difference between the two gases. In operation, the meter will then give a direct reading of the gas being measured.

This calibration is illustrated in the following examples:
(PS = Photoionization Sensitivity. See Table 8-14)

a. Given a case in which:

- 1) The trace gas to be measured is Vinyl Chloride
(PS = 5.0)
- 2) The calibration gas to be used is Isobutylene
(PS = 7.0) at a 100 ppm level

What is the ppm reading to be when calibrating to give a direct reading when measuring Vinyl Chloride?

The required reading for calibration will be:

$$\begin{aligned} &= \text{Isobutylene ppm} \times \frac{\text{PS(Isob)}}{\text{PS(Vin Chlor)}} \\ &= 100 \times \frac{7.0}{5.0} \\ &= 140 \text{ ppm} \end{aligned}$$

In this example, using a calibration gas with 100 ppm of Isobutylene, adjust the SPAN control so the meter reads 140 ppm. In operation, the instrument will then give a direct reading of the ppm of Vinyl Chloride.

b. Given a case in which:

- 1) The trace gas to be measured is Benzene (PS = 10.0)
- 2) The calibration gas to be used is Isobutylene
(PS = 7.0) at a level of 100 ppm
- 3) What is the ppm reading to be when calibrating to give a direct reading when measuring Benzene.

STATIC CALIBRATION CALCULATIONS

GAS SAMPLING BAG

Precision: +/- 10%

Range: 20 ppm to 1 percent (see NOTE 1)

Sample Calculations:

Gaseous Sample: Assume 0.15 ml of a pure gas, e.g., vinyl chloride, is injected into the container with 1.5 liters of hydrocarbon-free air by the syringe. The concentration then is:

$$\frac{\text{volume injected (ml)}}{\text{vessel volume (ml)}} \times 10 = \frac{0.15 \text{ ml}}{1500 \text{ ml}} \times 10 = 100 \text{ ppm}$$

Liquid sample: Assume 1.0 microliters of a volatile liquid such as toluene is injected into the container and 1.5 liter syringe filled with hydrocarbon-free air is added. The concentration then is:

$$\frac{\text{volume injected (ml)} \times \text{density (g/ml)}}{\text{molecular weight (g/mole)} \times \text{volume of air (liters)}} \times 10 = \frac{0.001 \text{ ml} \times 0.87 \text{ g/ml} \times 24.0 \text{ liters/mole}}{92 \text{ g/mole} \times 1.5 \text{ liters}} \times 10 = 151 \text{ ppm (see NOTE 2)}$$

NOTES: 1. Larger gas and liquid syringes are needed for the upper portion of this range.

WARNING

Note the toxic levels and the Lower Explosive Limits for personal safety. The PI 101 is a nondestructive analyzer and must be used in a hood when calibrating with toxic or hazardous materials.

2. The molar volume of toluene at 20 oC and one atmosphere is 24.0. This value must be corrected for the actual conditions, otherwise errors as high as 20% might be encountered. Corrections are made using the standard gas laws.

SECTION 8 cont.

3.4 UNCALIBRATED OPERATION

Best operation of the analyzer is accomplished by its calibration for the gas to be measured. In cases where it becomes necessary to operate with a gas for which it has not been calibrated and recalibration is not possible, correction can be made to the meter reading.

One method is by use of a chart. Figure 8-2 is such a chart. It shows performance curves for various gases being measured by an instrument with a 10.2 eV lamp and calibrated for benzene. This illustrates the effect of the different sensitivities of gases. These curves can be used directly for correcting a meter reading if the instrument is calibrated for benzene and is measuring one of the gases shown. For example, if the gas being measured is Propylene and the reading is 8 ppm, then the actual concentration is about 20 ppm.

A second method is to multiply the meter reading by a correction factor as follows:

$$\text{Actual ppm} = \text{ppm reading} \times \frac{\text{PS (Cal gas)}}{\text{PS (Trace gas)}}$$

in which

PS is the photoionization sensitivity of each of the two gases. Table 8-14 gives a list of the relative photoionization sensitivities of a number of specific gases with which the analyzer might be used. Use of this method is illustrated by the following examples:

- a. Instrument calibrated for Benzene (PS = 10.0)
and measuring Acetone (PS = 6.3)

$$\begin{aligned} \text{Actual ppm} &= \text{ppm reading} \times \frac{10.0}{6.3} \\ &= \text{ppm reading} \times 1.6 \end{aligned}$$

- b. Instrument calibrated for Vinyl Chloride
(PS = 5.0) and measuring Carbon Disulfide (PS = 7.1)

$$\begin{aligned} \text{Actual ppm} &= \text{ppm reading} \times \frac{5.0}{7.1} \\ &= \text{ppm reading} \times 0.7 \end{aligned}$$

These values are valid only for an analyzer with a 10.2 eV lamp. Different sensitivities occur with 9.5 and 11.7 eV lamps.

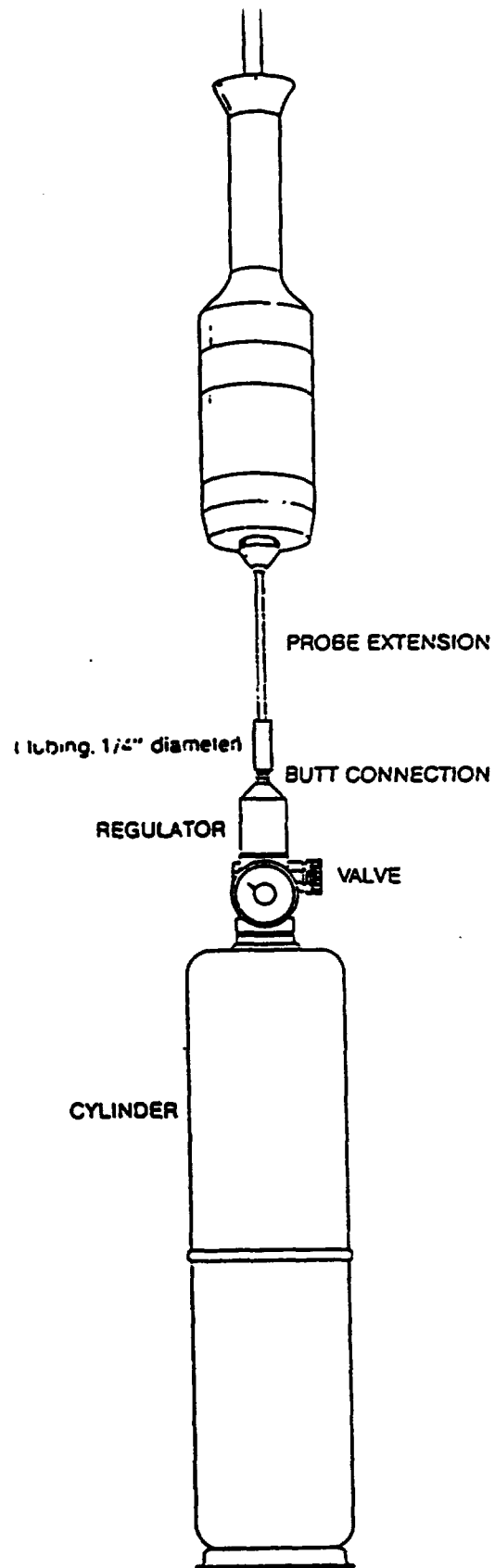


FIGURE 8-1
CALIBRATION CHECKING SET-UP

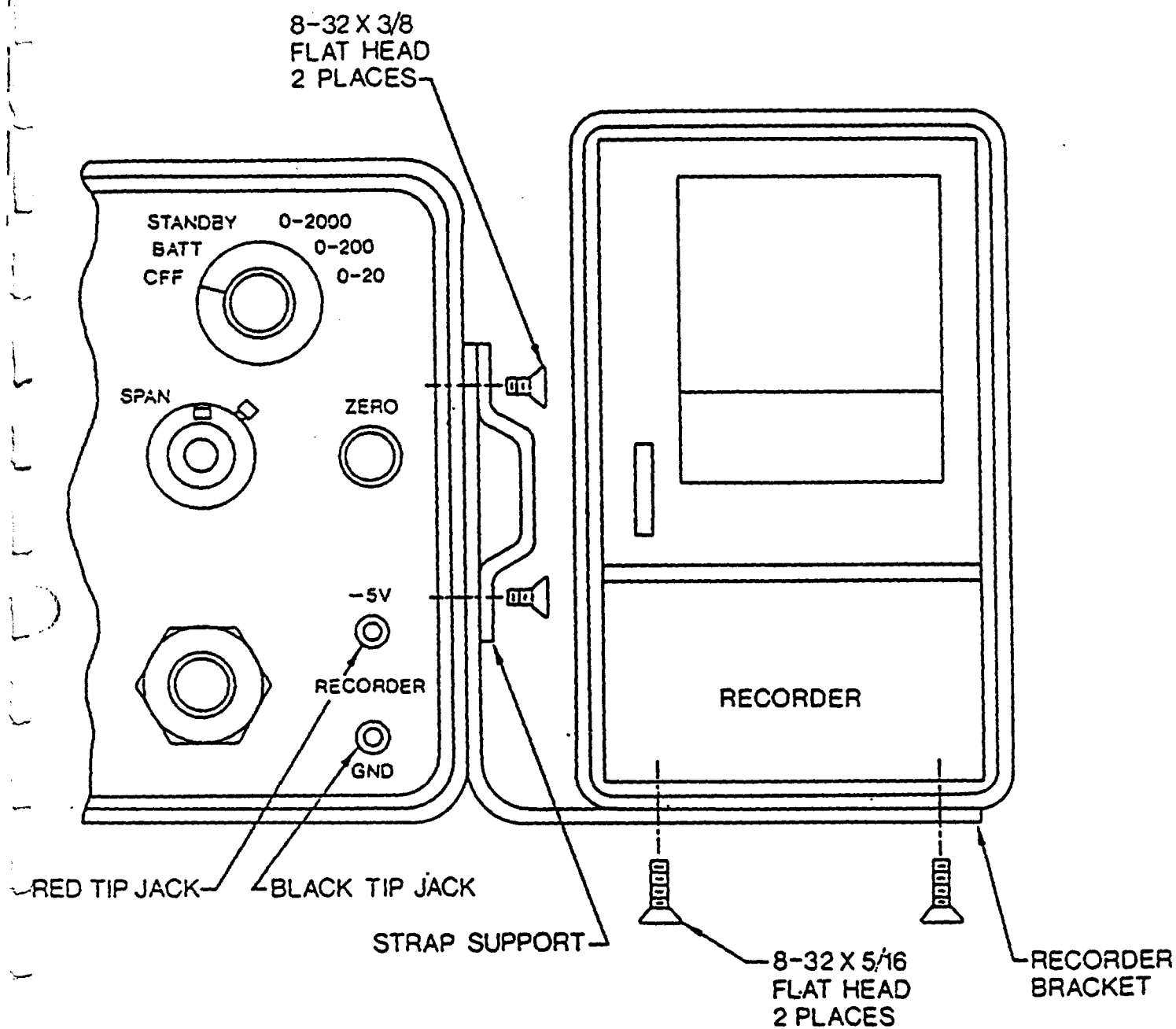


FIGURE 8-3

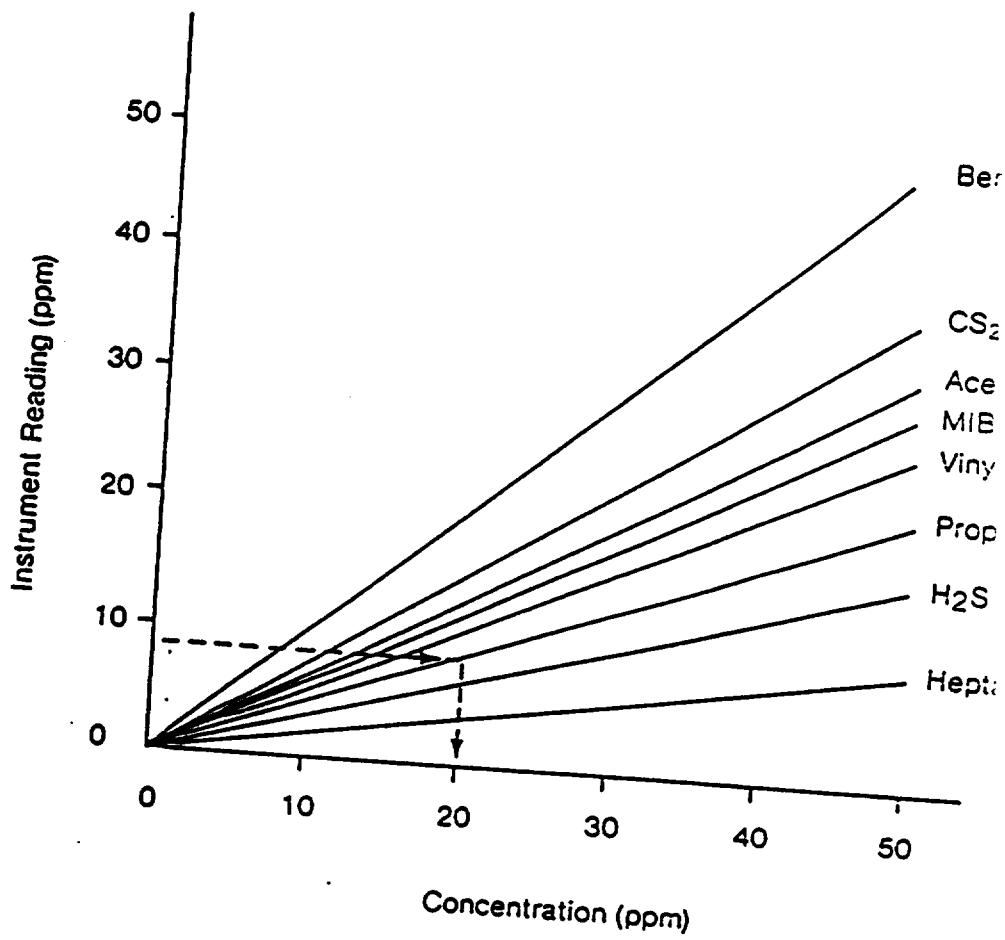


FIGURE 8-2
TYPICAL OUTPUT CURVES.-
ANALYZER WITH 10.2 eV LAMP
CALIBRATED FOR BENZENE

TABLE 8.1

SOME ATOMS AND SIMPLE MOLECULES

	IP (eV)		IP (eV)
H	13.595	I ₂	9.28
C	11.264	HF	15.77
N	14.54	HCl	12.74
O	13.614	HBr	11.62
Si	8.149	HI	10.38
S	10.357	SO ₂	12.34
F	17.42	CO ₂	13.79
Cl	13.01	COS	11.18
Br	11.84	CS ₂	10.08
I	10.48	N ₂ O	12.90
H ₂	15.426	NO ₂	9.78
N ₂	15.580	O ₃	12.60
O ₂	12.075	H ₂ O	12.59
CO	14.01	H ₂ S	10.46
CN	15.13	H ₂ Se	9.88
NO	9.25	H ₂ Te	9.14
CH	11.1	HCN	13.91
OH	13.18	C ₂ N ₂	13.8
F ₂	15.7	NH ₃	10.15
Cl ₂	11.48	CH ₃	9.840
Br ₂	10.55	CH ₄	12.98

TABLE 8.2

PARAFFINS AND CYCLOPARAFFINS

Molecule	IP (eV)
methane	12.98
ethane	11.65
propane	11.07
n-butane	10.63
i-butane	10.57
n-pentane	10.35
i-pentane	10.32
2, 2-dimethylpropane	10.35
n-hexane	10.16
2-methylpentane	10.12
3-methylpentane	10.08
2, 2-dimethylbutane	10.05
2, 3-dimethylbutane	10.02
n-heptane	10.06
2,2,4-trimethylpentane	9.86
cyclopropane	10.06
cyclopentane	10.53
cyclohexane	9.86
methylcyclohexane	9.85

TABLE 8.3

ALKYL HALIDES

Molecule	IP (eV)
HCl	12.74
Cl ₂	11.48
CH ₄	12.98
methyl chloride	11.28
dichloromethane	11.35
trichloromethane	11.42
tetrachloromethane	11.47
ethyl chloride	10.96
1,2-dichloroethane	11.12
1-chloropropane	10.82
2-chloropropane	10.78
1,2-dichloropropane	10.87
1,3-dichloropropane	10.85
1-chlorobutane	10.67
2-chlorobutane	10.65
1-chloro-2-methylpropane	10.66
2-chloro-2-methylpropane	10.61
HBr	11.62
Br ₂	10.55
methyl bromide	10.53
dibromomethane	10.49
tribromomethane	10.51
CH ₂ BrCl	10.77
CHBr ₂ Cl	10.59
ethyl bromide	10.29
1,1-dibromoethane	10.19
1-bromo-2-chloroethane	10.63

TABLE 8.3 (continued)

Molecule	IP (eV)
1-bromopropane	10.18
2-bromopropane	10.075
1,3-dibromopropane	10.07
1-bromobutane	10.13
2-bromobutane	9.98
1-bromo-2-methylpropane	10.09
2-bromo-2-methylpropane	9.89
1-bromopentane	10.10
HI	10.38
I ₂	9.26
methyl iodide	9.54
diiodomethane	9.34
ethyl iodide	9.33
1-iodopropane	9.26
2-iodopropane	9.17
1-iodobutane	9.21
2-iodobutane	9.09
1-iodo-2-methylpropane	9.16
2-iodo-2-methylpropane	9.02
1-iodopentane	9.19
F ₂	15.7
HF	15.77
CFCl ₃ (Freon 11)	11.77
CF ₂ Cl ₂ (Freon 12)	12.31
CF ₃ Cl (Freon 13)	12.91
CHClF ₂ (Freon 22)	12.45
CFBr ₃	10.67

TABLE 8.3 (continued)

Molecule	IP (eV)
CF ₂ Br ₂	11.07
CH ₃ CF ₂ Cl (Genetron 101)	11.98
CFCI ₂ CF ₂ Cl	11.99
CF ₃ CCl ₃ (Freon 113)	11.78
CFHBrCH ₂ Br	10.75
CF ₂ BrCH ₂ Br	10.83
CF ₃ CH ₂ I	10.00
n-C ₃ F ₇ I	10.35
n-C ₃ F ₇ CH ₂ Cl	11.84
n-C ₃ F ₇ CH ₂ I	9.96

TABLE 8.4

ALIPHATIC ALCOHOL, ETHER, THIOL,
AND SULFIDES

Molecule	IP (eV)
H ₂ O	12.59
methyl alcohol	10.85
ethyl alcohol	10.48
n-propyl alcohol	10.20
i-propyl alcohol	10.16
n-butyl alcohol	10.04
dimethyl ether	10.00
diethyl ether	9.53
n-propyl ether	9.27
i-propyl ether	9.20
H ₂ S	10.46
methanethiol	9.440
ethanethiol	9.285
1-propanethiol	9.195
1-butanethiol	9.14
dimethyl sulfide	8.685
ethyl methyl sulfide	8.55
diethyl sulfide	8.430
di-n-propyl sulfide	8.30

TABLE 8.5

ALIPHATIC ALDEHYDES AND KETONES

Molecule	IP (eV)
CO ₂	13.79
formaldehyde	10.87
acetaldehyde	10.21
propionaldehyde	9.98
n-butyraldehyde	9.86
isobutyraldehyde	9.74
n-valeraldehyde	9.82
isovaleraldehyde	9.71
acrolein	10.10
crotonaldehyde	9.73
benzaldehyde	9.53
acetone	9.69
methyl ethyl ketone	9.53
methyl n-propyl ketone	9.39
methyl i-propyl ketone	9.32
diethyl ketone	9.32
methyl n-butyl ketone	9.34
methyl i-butyl ketone	9.30
3, 3-dimethyl butanone	9.17
2-heptanone	9.33
cyclopentanone	9.26
cyclohexanone	9.14
2, 3-butanedione	9.23
2, 4-pentanedione	8.67

TABLE 8.6

ALIPHATIC ACIDS AND ESTERS

Molecule	IP (eV)
CO ₂	13.79
formic acid	11.05
acetic acid	10.37
propionic acid	10.24
n-butyric acid	10.16
isobutyric acid	10.02
n-valeric acid	10.12
methyl formate	10.515
ethyl formate	10.61
n-propyl formate	10.54
n-butyl formate	10.50
isobutyl formate	10.46
methyl acetate	10.27
ethyl acetate	10.11
n-propyl acetate	10.04
isopropyl acetate	9.99
n-butyl acetate	10.01
isobutyl acetate	9.97
sec-butyl acetate	9.91
methyl propionate	10.15
ethyl propionate	10.00
methyl n-butyrate	10.07
methyl isobutyrate	9.95

TABLE 8.7

ALIPHATIC AMINES AND AMIDES

Molecule	IP (eV)
NH ₃	10.15
methyl amine	8.97
ethyl amine	8.86
n-propyl amine	8.78
i-propyl amine	8.72
n-butyl amine	8.71
i-butyl amine	8.70
s-butyl amine	8.70
t-butyl amine	8.64
dimethyl amine	8.24
diethyl amine	8.01
di-n-propyl amine	7.84
di-i-propyl amine	7.73
di-n-butyl amine	7.69
trimethyl amine	7.82
triethyl amine	7.50
tri-n-propyl amine	7.23
formamide	10.25
acetamide	9.77
N-methyl acetamide	8.90
N,N-dimethyl formamide	9.12
N,N-dimethyl acetamide	8.81
N,N-diethyl formamide	8.89
N,N-diethyl acetamide	8.60

TABLE 8.8

OTHER ALIPHATIC MOLECULES WITH N ATOM

Molecule	IP (eV)
nitromethane	11.08
nitroethane	10.88
1-nitropropane	10.81
2-nitropropane	10.71
HCN	13.91
acetonitrile	12.22
propionitrile	11.84
n-butyronitrile	11.67
acrylonitrile	10.91
3-butene-nitrile	10.39
ethyl nitrate	11.22
n-propyl nitrate	
methyl thiocyanate	10.065
ethyl thiocyanate	9.89
methyl isothiocyanate	9.25
ethyl isothiocyanate	9.14

TABLE 8.9

OLEFINS, CYCLO-OLEFINS,
ACETYLENES

Molecule	IP (eV)
ethylene	10.515
propylene	9.73
1-butene	9.58
2-methylpropene	9.23
trans-2-butene	9.13
cis-2-butene	9.13
1-pentene	9.50
2-methyl-1-butene	9.12
3-methyl-1-butene	9.51
3-methyl-2-butene	8.67
1-hexene	9.46
1,3-butadiene	9.07
isoprene	8.845
cyclopentene	9.01
cyclohexene	8.945
4-methylcyclohexene	8.91
4-cinylcyclohexene	8.93
cyclo-octatetraene	7.99
acetylene	11.41
propyne	10.36
1-butyne	10.18

TABLE 8.10

SOME DERIVATIVES OF OLEFINS

Molecule	IP (eV)
vinyl chloride	9.995
cis-dichloroethylene	9.65
trans-dichloroethylene	9.66
trichloroethylene	9.45
tetrachloroethylene	9.32
vinyl bromide	9.80
1,2-dibromoethylene	9.45
tribromoethylene	9.27
3-chloropropene	10.04
2,3-dichloropropene	9.62
1-bromopropene	9.30
3-bromopropene	9.7
$\text{CF}_3\text{CCl}=\text{CClCF}_3$	10.36
$\text{n-C}_5\text{F}_{11}\text{CF}=\text{CF}_2$	10.46
acrolein	10.10
crotonaldehyde	9.73
mesityl oxide	9.08
vinyl methyl ether	8.93
allyl alcohol	9.67
vinyl acetate	9.19

TABLE 8.11

HETEROCYCLIC MOLECULES

Molecule	IP (eV)
furan	8.69
2-methyl furan	8.39
2-furaldehyde	9.21
tetrahydrofuran	9.54
dihydropyran	8.34
tetrahydropyran	9.26
thiophene	8.660
2-chlorothiophene	8.55
2-bromothiophene	8.63
pyrrole	8.20
pyridine	9.32
2-picoline	9.02
3-picoline	9.04
4-picoline	9.04
2,3-lutidine	8.85
2,4-lutidine	8.85
2,5-lutidine	8.85

TABLE 8.12

AROMATIC COMPOUNDS

Molecule	IP (eV)
benzene	9.245
toluene	8.82
ethyl benzene	8.76
n-propyl benzene	8.72
i-propyl benzene	8.69
n-butyl benzene	8.69
s-butyl benzene	8.68
t-butyl benzene	8.68
o-xylene	8.56
m-xylene	8.56
p-xylene	8.445
mesitylene	8.40
durene	8.025
styrene	8.47
α -methyl styrene	8.35
ethynylbenzene	8.815
naphthalene	8.12
1-methylnaphthalene	7.69
2-methylnaphthalene	7.955
biphenyl	8.27
phenol	8.50
anisole	8.22
phenetole	8.13
benzaldehyde	9.53
acetophenone	9.27
benzenethiol	8.33
phenyl isocyanate	8.77

TABLE 8.12 (continued)

Molecule	IP (eV)
phenyl isothiocyanate	8.520
benzonitrile	9.705
nitrobenzene	9.92
aniline	7.70
fluoro-benzene	9.195
chloro-benzene	9.07
bromo-benzene	8.98
iodo-benzene	8.73
o-dichlorobenzene	9.07
m-dichlorobenzene	9.12
p-dichlorobenzene	8.94
1-chloro-2-fluorobenzene	9.155
1-chloro-3-fluorobenzene	9.21
1-bromo-4-fluorobenzene	8.99
o-fluorotoluene	8.915
m-fluorotoluene	8.915
p-fluorotoluene	8.785
o-chlorotoluene	8.53
m-chlorotoluene	8.53
p-chlorotoluene	8.70
o-bromotoluene	8.79
m-bromotoluene	8.81
p-bromotoluene	8.67
o-iodotoluene	8.62
m-iodotoluene	8.61
p-iodotoluene	8.50
benzotrifluoride	9.68
o-fluorophenol	8.66

TABLE 8.1

MISCELLANEOUS M

Molecule	IP
ethylene oxide	10
propylene oxide	10
p-dioxane	9.1
dimethoxymethane	10
diethoxymethane	9.7
1,1-dimethoxyethane	9.6
propiolactone	9.7
methyl diisocyanate	8.4
ethyl diisocyanate	8.2
diethyl diisocyanate	9.5
thiolacetone	10
acetyl chloride	11
acetyl bromide	10
cyclo-C ₅ H ₁₁ O	10
(n-C ₃ F ₇)(CH ₃)O	10
trichlorovinylsilane	10
(C ₂ F ₅) ₃ N	11
isoprene	9.0
phosgene	11

TABLE 3-14

RELATIVE PHOTOIONIZATION SENSITIVITIES OF
VARIOUS GASES TO A 10.2 eV LAMP

Gas	Photoionization Sensitivity (see Note 1)	Span Control Setting for Direct reading (approximate)
p-xylene	11.4	
m-xylene	11.2	
benzene	10.0 (reference standard)	9.5
toluene	10.0	
diethyl sulfide	10.0	
diethyl amine	9.9	
styrene	9.7	
trichloroethylene	9.6	8.2
carbon disulfide	7.1	
isobutylene	7.0	
acetone	6.2	
tetrahydrofuran	6.0	5.5
methyl ethyl ketone	5.7	
methyl isobutyl ketone	5.7	
cyclohexanone	5.1	
naptha (55% aromatics)	5.0	
vinyl chloride	5.0	4.3
methyl isocyanate	4.5	
iodine	4.5	
methyl mercaptan	4.3	

TABLE C-14 cont.

dimethyl sulfide	4.3	
allyl alcohol	4.2	
propylene	4.0	3.5
mineral spirits	4.0	
2, 3-dichloropropene	4.0	
cycloexene	3.4	
crotonaldehyde	3.1	
acrolein	3.1	
methyl methacrylate	3.0	2.4
pyridine	3.0	
hydrogen sulfide	2.8	
ethylene dibromide	2.7	1.0
n-octane	2.5	
acetaldehyde oxime	2.3	
hexane	2.2	
phosphine	2.0	
heptane	1.7	
allyl chloride	1.5	
(3-chloropropene)		
ethylene	1.0	
isopropanol	1.0	0.1
ethylene oxide	1.0	
acetic anhydride	1.0	
alpha pinene	0.7	
dibromochloropropane	0.7	

TABLE 3-14 cont.

epichlorohydrin	0.7
nitric oxide	0.6
beta pinene	0.5
citral	0.5
ammonia	0.3
acetic acid	0.1
nitrogen dioxide	0.02
methane	0.0
acetylene	0.0

NOTE 1: PPM reading when measuring 10.0 ppm of particular gas with monitor calibrated for benzene.

TABLE E-15

RELATIVE PHOTOIONIZATION SENSITIVITIES OF
VARIOUS GASES TO A 11.7 eV LAMP

Direct Gas (Approx.)	Photoionization Sensitivity (See Note 1)	Span Control Setting for Direct Reading (Approx.)
Carbon Disulfide	33.0	
Heptane	22.1	
Hexane	18.9	
Pentane	14.1	
1,2 Dichloroethane	12.9	
Benzene	12.2	5.0
MIBK	10.6	
Isobutylene	10.0 (Reference Std.)	
Toluene	10.0	
Methyl Chloride	9.8	
Methylene Chloride	9.4	
111 Trichloroethane	9.0	
Carbon Tetrachloride	9.0	
Ethylene Dichloride	9.0	
Butane	8.7	
THF	7.9	
Acrylonitrile	7.1	2.0
MEK	6.3	
Chloroform	6.0	
1,1,2,2 Tetrachloroethane	6.0	
Acetone	5.7	
Propane	5.5	
Isopropanol	4.5	
Acrolein	3.4	1.0
Ethane	3.0	
Ethanol	3.0	
Methanol	1.0	
1,1,2 Trifluoroethane	0.3	
Acetonitrile	0.1	

NOTE 1: PPM reading when measuring 10.0 ppm of
particular gas with monitor calibrated for benzene.

TABLE 2-16

RELATIVE PHOTOIONIZATION SENSITIVITIES
OF VARIOUS GASES TO A 9.5 eV LAMP

Direct Gas (Approx.)	Photoionization Sensitivity (See Note 1)	Span Control Setting for Direct Reading (Approx.)

Xylene	11.2	
Benzene	10.0 (Reference Std.)	1.0
Styrene	10.0	
Toluene	10.0	
Phenol	7.7	
Aniline	3.9	
MEK	2.9	
Pyridine	2.2	
Acetone	0.65	
Methyl Methacrylate	<0.5*	
Heptane	<0.2*	
Hexane	0	
Ammonia	0	
Pentane	0	

* Commercial products containing impurities; response for pure materials is probably less.

NOTE 1: PPM reading when measuring 10.0 ppm of particular gas with monitor calibrated for benzene.

SECTION 8 cont.

8.7 WARRANTY

HNU Systems, Incorporated, warrants all items to be free from defects in material and workmanship when used under normal operating conditions. HNU's liability hereunder shall be limited to the repair or replacement of the articles ascertained to be defective within one (1) year after date of shipment (except that the light source warranty is limited to three (3) months and does not include breakage, and battery warranty is limited to three (3) months), provided, however that the Buyer shall give notice to HNU within thirty (30) days after discovery of such defective material and provided further that all defective material be shipped prepaid to the HNU plant within a reasonable time from the date of discovery of the defect and during such warranty period. After the repair or replacement, HNU will ship the said item to Buyer, transportation charges prepaid, to any point in the United States that Buyer may designate.

THE FOREGOING IS THE SOLE EXTENT OF HNU'S WARRANTY AND NO OTHER STATEMENTS OR WARRANTIES, EXPRESSED OR IMPLIED, SHALL BE HONORED. UNDER NO CIRCUMSTANCES SHALL HNU BE SUBJECT TO ANY LIABILITY FOR SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES.

SECTION 8 cont.

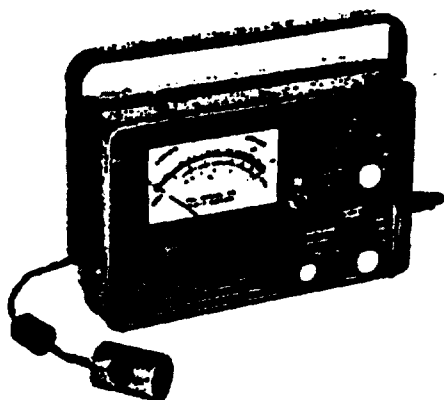
8.8 Publications on Photoionization Available from HNU Systems, Inc.

101-10 Industrial Hygiene Monitoring With A Variable
Selectivity Photoionization Analyzer.
J.N. Driscoll and J.H. Becker,
American Laboratory, November 1979.

101-12 Instrumentation for "On Site" Survey and Identification
of Hazardous Waste.
J.N. Driscoll and G.F. Hewitt,
Industrial Hygiene News, May 1982

101-17 Instrument Calibration with Toxic and Hazardous
Materials.
J.H. Becker, J.N. Driscoll, D. Renaud, P. Tiffany,
C. Sylvia,
Industrial Hygiene News, July 1983.

YSI MODELS 33 AND 33M S-C-T METERS INSTRUCTIONS



GENERAL DESCRIPTION

The YSI Model 33 and 33M S-C-T Meters are portable, battery powered, transistorized instruments designed to accurately measure salinity, conductivity and temperature. They use a probe consisting of a rugged, plastic conductivity cell and a precision YSI thermistor temperature sensor combined in a single unit.

Conductivity with the Model 33 is expressed as microhmhos/centimeter; with the 33M, it is millisiemens/meter (mS/m). These are measurements of the electrical conductance the sample would show if measured between opposite faces of a 1 cm cube. (Conversion information: 1 microhmho/cm = 0.1 mS/m.) Salinity is the number of grams of salt/kilogram of sample (ppt = parts per thousand). This measurement assumes the sample contains a "standard" sea water salt mixture. The sample temperature is measured in degrees Celsius.

Salinity measurements are manually temperature compensated by direct dial. Conductivity measurements are not temperature compensated; however, a temperature function is provided on the instrument to aid with calculation of corrections. When temperature and conductivity are known, it is possible to calculate salinity; and when only temperature and salinity are known, it is possible to calculate conductivity. This is discussed in the section on Recalibration.

SPECIFICATIONS

Model 33 Conductivity

Ranges: 0 to 500 (x1), 0 to 5,000 (x10), and 0 to 50,000 microhmhos/cm (x100) with YSI 3300 Series Probes. (Note: The "microhmho" designations on the meter are a shorthand form for "microhmho/cm".)

Accuracy: (See Error Section)
±2.5% max. error at 500, 5,000 and 50,000 plus probe.
±3.0% max. error at 250, 2,500 and 25,000 plus probe.

Readability:

2.5 microhmhos/cm on 500 microhmho/cm range.
25 microhmhos/cm on 5,000 microhmho/cm range.
250 microhmhos/cm on 50,000 microhmho/cm range.

Temperature Compensation: None.

Model 33M Conductivity

Ranges:

0 to 50 (x1), 0 to 500 (x10), and 0 to 5,000 (x100) mS/m with YSI 3300 Series Probes.

Accuracy: (See Error Section)

±2.5% max. error at 50, 500, and 5,000 plus probe.
±3.0% max. error at 25, 250, and 2,500 plus probe.

Readability:

0.25 mS/m on 50 mS/m range.
2.5 mS/m on 500 mS/m range.
25.0 mS/m on 5,000 mS/m range.

Temperature Compensation: None.

Salinity

Range: 0-40 ppt in temperature range of -2 to within specified conductivity range of 0 to microhmho/cm (0 to 5,000 mS/m). See chart in section Recalibration.

Accuracy (See Error Section)

Above 4°C: ±0.9 ppt at 40 ppt and ±0.7 ppt at 20 ppt plus conductivity probe.

Below 4°C: ±1.1 ppt at 40 ppt and ±0.9 ppt at 20 ppt plus conductivity probe.

Readability: 0.2 ppt on 0-40 ppt range.

Temperature Compensation: Manual by direct dial from -2 to +45°C.

Temperature Range: -2 to +50°C.

Accuracy: ±0.1°C at -2°C, ±0.6°C at 45°C plus probe (See Error Section)

Readability: ±0.15°C at -2°C to ±0.37°C at 45°C.

Power Supply: Two D-size alkaline batteries, Eveready E95 or equivalent, provide approximately 200 hours of operation.

Instrument Ambient Range: -5 to +45°C. A maximum error of ±0.1% of the reading per °C change in instrument temperature can occur. This error is negligible if the instrument is readjusted to redline for each reading.



YSI Scientific

Yellow Springs, Ohio 45387 USA • Phone 513 767-7241 • 800 343-HELP

YSI 3300 Series Conductivity/Temperature Probe

Nominal Probe Constant: $K = 5/\text{cm}$ ($K = 500/\text{m}$)

Accuracy: $\pm 2\%$ of reading for conductivity and salinity.

Error of $\pm 0.1^\circ\text{C}$ at 0°C and $\pm 0.3^\circ\text{C}$ at 40°C .

OPERATION

Setup

1. Adjust meter zero (if necessary) by turning the bakelite screw on the meter face so that the meter needle coincides with the zero on the conductivity scale.
2. Calibrate the meter by turning the MODE control to REDLINE and adjusting the REDLINE control so the meter needle lines up with the redline on the meter face. If this cannot be accomplished, replace the batteries.
3. Plug the probe into the probe jack on the side of the instrument.
4. Put the probe in the solution to be measured. (See Probe Use.)

Temperature

Set the MODE control to TEMPERATURE. Allow time for the probe temperature to come to equilibrium with that of the water before reading. Read the temperature on the bottom scale of the meter in degrees Celsius.

Conductivity

1. Switch to X100. If the reading is below 50 on the 0-500 range (5.0 on the 0-50 mS/m range), switch to X10. If the reading is still below 50 (5.0 mS/m), switch to the X1 scale. Read the meter scale and multiply the reading appropriately. The answer is expressed in micromhos/cm (mS/m). Measurements are not temperature compensated.

Example

Meter Reading: 247 (24.7 mS/m)
Scale: X10
Answer: 2470 micromhos/cm (247.0 mS/m)

2. When measuring on the X100 and X10 scales, depress the CELL TEST button. The meter reading should fall less than 2%; if greater, the probe is fouled and the measurement is in error. Clean the probe and re-measure.

NOTE: The CELL TEST does not function on the X1 scale.

Salinity

1. Determine the sample temperature and adjust the temperature dial to that value.
2. Switch to X100. If the reading is above 500 micromho/cm (50 mS/m), the salinity value is beyond the measurement range.
3. If the reading is in range, switch to SALINITY and read salinity on the red 0-40 ppt meter scale.
4. Depress the CELL TEST button. The fall in meter reading should be less than 2%; if it is greater, the probe is fouled and the measurement is in error. Clean the probe and re-measure.

Error

The maximum error in a reading can be calculated by using the graphs in the following sections.

Temperature Error

The temperature scale is designed to give the minimum salinity error when temperature readings are used to compensate salinity measurements.

Figure 1 shows total error for probe and instrument versus $^\circ\text{C}$ meter reading.

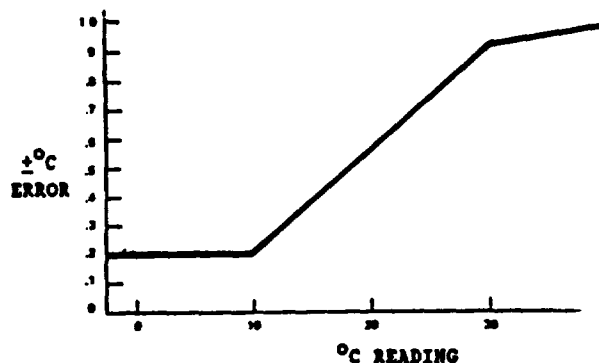


FIGURE 1

Example:

Meter Reading: 15°C
Total Error: 0.4°C
Accuracy: $15^\circ\text{C} \pm 0.4^\circ\text{C}$ for probe and instrument combined.

Conductivity Error

Figure 2 shows the worst-case conductivity error as a function of the conductivity reading for the probe and instrument combined.

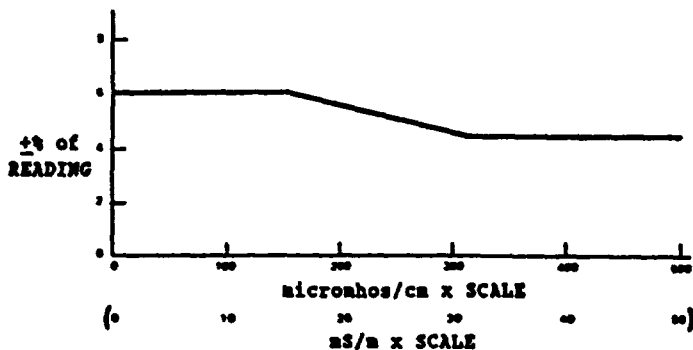


FIGURE 2

Example

Meter Reading: 360 micromhos/cm (36 mS/m)
Scale: X10
Reading Error: $\pm 4.5\%$
Accuracy: 3600 ± 162 micromhos/cm (360 ± 16.2 mS/m) for probe and instrument

The salinity readings are a function of temperature and conductivity, therefore the accuracy is a function of both.

Graph showing the percentage of reading versus DDT salinity reading for two temperatures: 27.0 ± 0.2°C and 29.0 ± 0.2°C. The y-axis is labeled '% of READING' and ranges from 0 to 10. The x-axis is labeled 'DDT SALINITY READING' and ranges from 0 to 40. Both curves show a sharp drop in reading percentage around a salinity reading of 15, with the 29.0°C curve dropping more sharply than the 27.0°C curve.

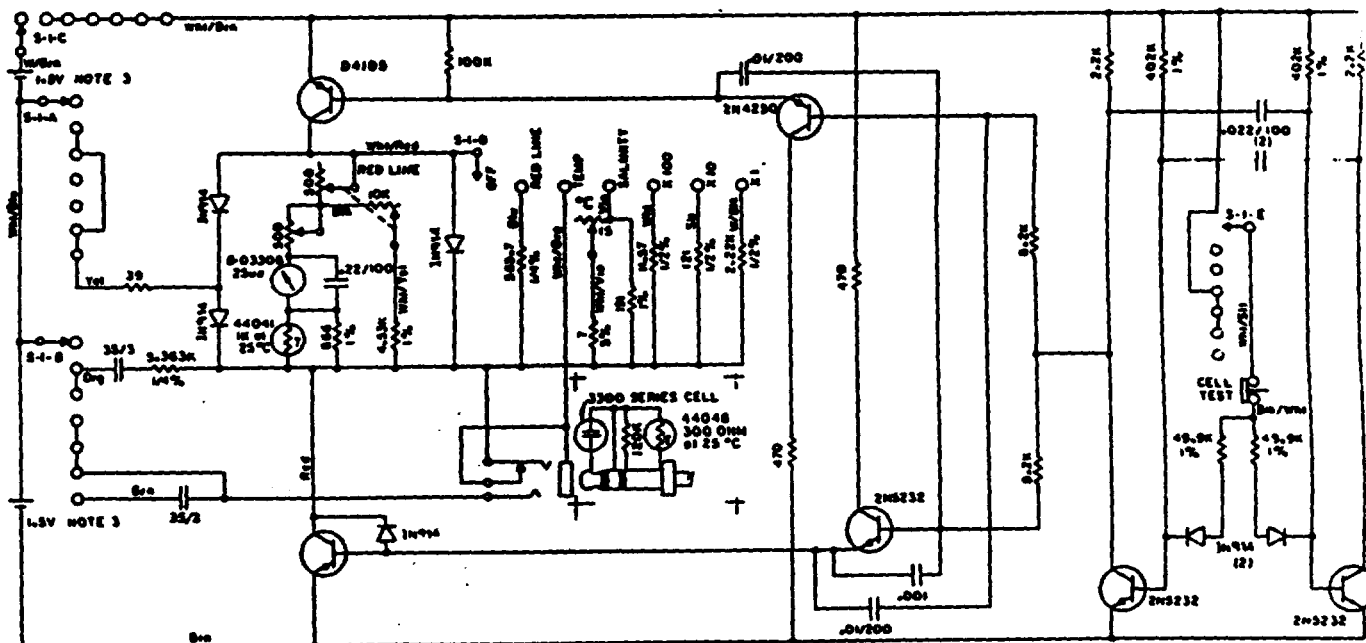
DDT SALINITY READING	% of READING (27.0 ± 0.2°C)	% of READING (29.0 ± 0.2°C)
0	~9.5	~8.5
10	~9.5	~8.5
15	~8.5	~7.5
20	~7.5	~6.5
25	~6.5	~5.5
30	~6.5	~5.5
40	~6.5	~5.5

Example
Meter Reading: 10 ppt, @ 10°C
% of Reading Error: 6.5%
Accuracy: 10 ppt ± 0.65 ppt for all errors,
 combined worst case.

The circuit is composed of two parts; a multivibrator and switching transistors. The multivibrator produces a square waveform voltage. The square wave is applied to two switching transistors. They alternately apply two batteries of opposite polarity to the probe thus providing AC power which minimizes polarization effects. The meter is in series with one battery and measures the current from it. The current from the battery is proportional to the conductance of the cell. Salinity is measured in a special range conductivity circuit which includes a user-adjusted temperature compensator. In the temperature, redline and X1 positions, the multivibrator operates at 100Hz. In the salinity, X100 and X10 positions the multivibrator operates at 600Hz; in these ranges, pushing the CELL TEST button drops the frequency to 100Hz, allowing the operator to test for probe polarization.

The only maintenance required is battery replacement. Two "D" size alkaline flashlight cells, such as Eveready E95 or equivalent, will provide 200 hrs. of operation. Accuracy will not be maintained if zinc-carbon "D" cells are used. Battery replacement is indicated when the redline adjustment cannot be accomplished.

Replace batteries every six months to reduce the of corrosion due to leaky batteries. To replace, remove the screws from the rear cover. battery holders are color coded. The positive end goes on red.



Resistance values in ohms. X = 1,000. Resistors are 1/2 W, 10%, unless otherwise specified.

This schematic is representative and may be slightly different from the circuit in your instrument.

RECALIBRATION

Recalibration should be done at the factory. If emergency recalibration is necessary, however, one of the procedures described below may be attempted.

Use this method if the temperature knob has become loose or slipped from its normal position.

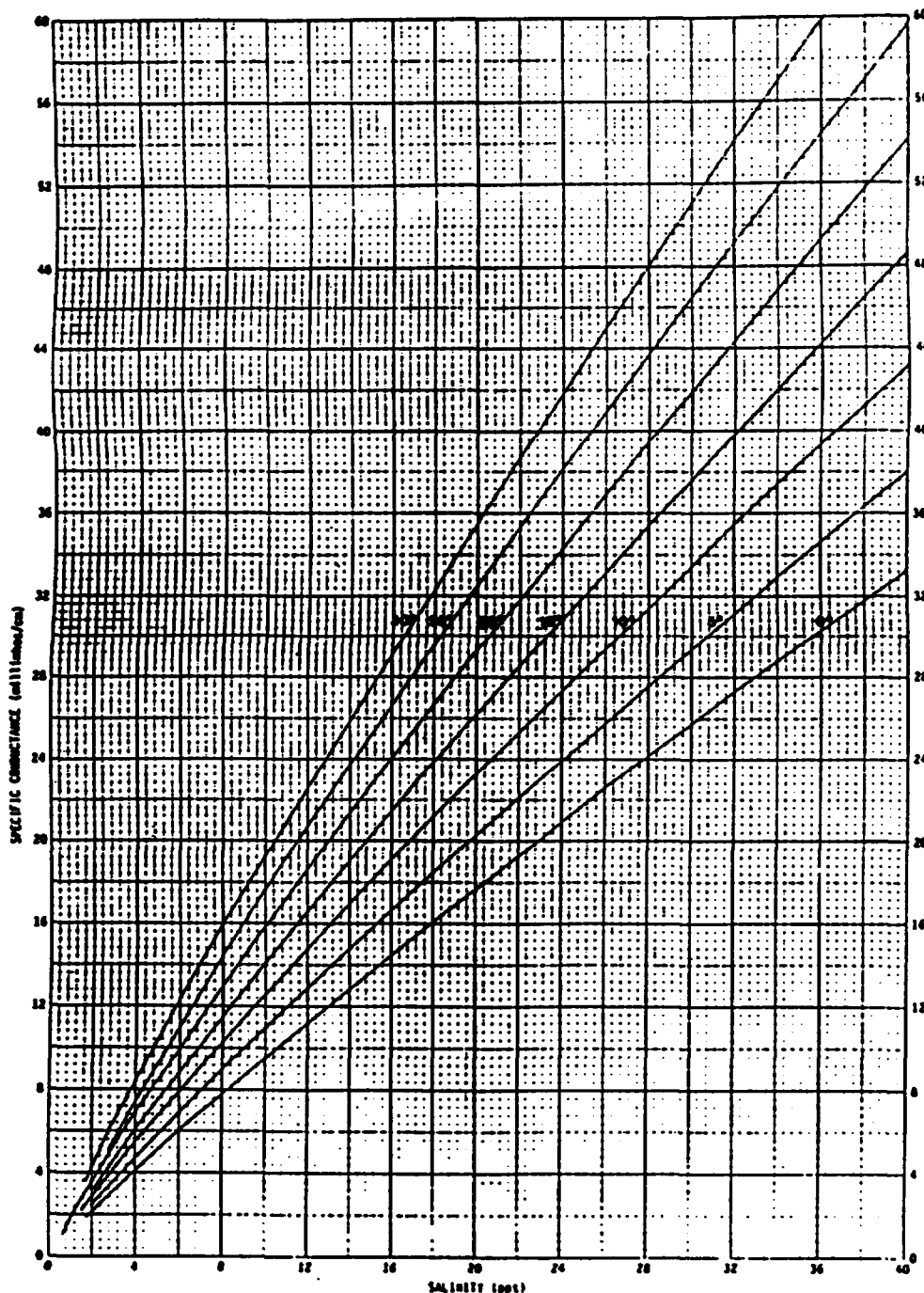
a. Read the temperature and conductivity of a sample. Determine the salinity of the solution by running a line vertically on the Calibration Graph from this conductance value until it intersects the appropriate °C line (interpolate as required for temperature between the given °C lines). From this intersection extend a line horizontally to the edge of the graph to

read the salinity for this sample.

Example: 25,000 micromhos/cm (2,500 mS/m) and 20°C gives a salinity of 17 ppt.

b. Remove the temperature knob, switch to SALINITY, and turn the control shaft until the meter needle indicates the salinity value determined in Step a. In the example given, the value is 17.

c. Switch to TEMPERATURE and note the reading. This reading must be the same as Step a; if it is not, begin again. Replace the knob (without turning the control shaft) with the pointer at the same temperature as the meter reading and tighten both set screws securely.

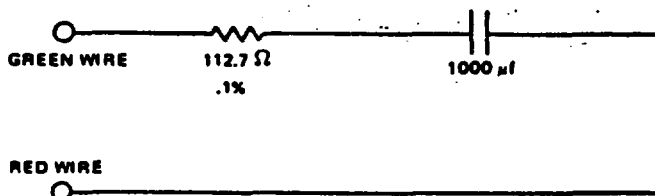


2. You may use the resistor and capacitor hookup shown in the sketch to substitute for the probe in the following recalibration procedure.

a. Set the instrument for a salinity measurement as normal.

b. Substitute a 1000 microfarad capacitor and 112.7 ohm 0.1% tolerance resistor for the probe.

Connect the resistor and capacitor between the green wire and red wire on the jack connections inside the instrument.



c. Turn the temperature dial until the meter reads redline.

d. Reinstall the temperature knob with the arrow at 25°C.

This is a temporary calibration only. Return the instrument to the factory for proper recalibration.

YSI 3300 SERIES CONDUCTIVITY/TEMPERATURE PROBES

Description

These probes are designed and constructed for rugged, accurate service in field use. The conductivity cell constant is 5.0/cm (500.0/m) $\pm 2\%$. Each probe contains a precision YSI thermistor temperature sensor of $\pm 0.1^\circ\text{C}$ accuracy at 0°C and $\pm 0.3^\circ\text{C}$ at 40°C . The low capacitance cable assembly terminates in a three terminal 0.25" dia. phone plug.

The 3310 has a 10 foot cable and the 3311 a 50 foot cable. Other lengths are available on special order.

The probe has a rigid P.V.C. body, platinized pure nickel electrodes, and a rugged cable.

Cleaning and Storage

Cleaning

When the cell test indicates low readings the probable cause is dirty electrodes. Hard water deposits, oils and organic matter are the most likely contaminants.

For convenient normal cleaning soak the electrodes for 5 minutes with a locally available bathroom tile cleaning preparation such as Dow Chemical "Bathroom and Chrome Cleaner," Johnson Wax "Envy, Instant Cleaner," or Lysol Brand "Basin, Tub, Tile Cleaner."

For stronger cleaning a 5 minute soak in a solution made of 10 parts distilled water, 10 parts isopropyl alcohol and 1 part HCl can be used.

Always rinse the probe thoroughly in tap water, then in distilled or deionized water after cleaning and before storage.

CAUTION: Do not touch the electrodes inside the probe. Platinum black is soft and can be scraped off.

If cleaning does not restore the probe performance, replatinizing is required.

Storage

It is best to store conductivity cells in deionized water. Cells stored in water require less frequent platinization. Any cell that has been stored dry should be soaked in deionized water for 24 hours before use.

Replatinization

1. Clean the probe.

2. Place the cell in a 50 ml (approximate) jar or beaker and add enough YSI 3140 Platinizing Solution to cover the electrodes. Do not cover the top of the probe.

3. Plug the probe into the Model 33 or 33M, switch to the X100 scale to platinize the electrodes. Move the probe slightly to obtain the highest meter reading and continue platinizing for the approximate time shown below:

Meter Reading micronhos/cm	mS/m	Time in minutes
30,000	3,000	5
25,000	2,500	6
20,000	2,000	8
15,000	1,500	11
10,000	1,000	16

4. After the elapsed time, remove the probe and rinse in tap water, then in distilled or deionized water.

5. Return the solution to its container. 2 oz. of solution should be sufficient for 50 treatments.

Probe Use and Precautions

1. Obstructions near the probe can disturb readings. At least two inches of clearance must be allowed from non-metallic underwater objects. Metallic objects such as piers or weights should be kept at least 6 inches from the probe.

2. Weights are attached to the cable of the YSI 3310 and 3311 Probes. The YSI 3327 Weights are supplied in pairs with a total weight of 4 ounces per pair. Should it become necessary to add more weight to overcome water currents, we suggest limiting the total weight to two pounds (8 pairs). For weights in excess of two pounds use an independent suspension cable. In either case, weights must be kept at least 6 inches away from the probe.

3. Gentle agitation by raising and lowering the probe several times during a measurement insures flow of specimen solution through the probe and improves the time response of the temperature sensor.

Conductivity and Salinity Corrections for Long Cables

The additional length of wire in long cables adds capacitance and resistance which will effect readings. The recommended way to correct for these influences is by use of YSI Conductivity Calibrator Solutions (see below), which will permit an estimate of correction factors. If these solutions are not available, the following tables can be used for the correction of errors caused by cable resistance and capacitance on special length versions of the 3310, 3311, S-1793 and S-16120 probes.

TABLE I: CONDUCTIVITY CORRECTIONS (IN % OF READING)

Indicated Conductivity		Cable Length in Feet						
Range umho/cm		10	50	100	200	300	500	1000
x1	100	-1.0	-5.0	NR	NR	NR	NR	NR
x1	500	-0.2	-1.0	-2.0	-4.0	-6.0	NR	NR
x10*	500	-1.2	-6.0	NR	NR	NR	NR	NR
x10	1000	-0.6	-3.0	-6.0	NR	NR	NR	NR
x10	5000	-0.1	-0.5	-1.0	-2.0	-3.0	-5.0	NR
x100	10000	-0.06	-0.3	-0.6	-1.2	-1.8	-3.0	-6.0
x100	50000	-0.01	-0.05	-0.1	-0.2	-0.3	-0.5	-1.0

* This row indicates the effect of the change from 100 Hz to 600 Hz when the instrument is switched to the x10 range.

NR represents conductivity levels which we do not recommend for probes with the indicated cable lengths.

TABLE II: TEMPERATURE CORRECTIONS IN °C

Indicated Temperature		Cable Length in Feet						
°C		10	50	100	200	300	500	1000
0		NONE	NONE	NONE	NONE	+0.1	+0.2	+0.4
10		NONE	NONE	NONE	+0.1	+0.2	+0.3	+0.6
20		NONE	NONE	+0.1	+0.2	+0.3	+0.5	+1.0
30		NONE	NONE	+0.1	+0.3	+0.4	+0.7	+1.4
40		NONE	+0.1	+0.2	+0.4	+0.7	+1.1	+2.2
50		NONE	+0.2	+0.3	+0.6	+1.0	+1.5	+3.1

NONE indicates that the corrections are less than 0.1°C.

TABLE III: SALINITY CORRECTIONS IN PARTS PER THOUSAND

Temperature Setting		% Conductivity Corrections from Table I		
°C		-1	-5	-10
0		-0.1	-0.5	-1.0
10		NONE	-0.4	-0.8
20		NONE	-0.3	-0.6
30		NONE	-0.25	-0.5
40		NONE	-0.2	-0.4
50		NONE	-0.12	-0.25

NOTES:

1. Conductivity corrections should be made from Table I, or by interpolation of the table.
2. Salinity corrections require determination of conductivity, hence conductivity correction, and the setting of corrected temperature readings prior to salinity measurements.
3. Use of these corrections should increase the error band for measurements by less than 10%.
4. If your measurement conditions are such that a 2% or greater conductivity correction is required, the cell test feature will not properly indicate a defective probe.

Cell Calibration and Standard Solutions

The cell constant of a conductivity cell may vary slightly with the conductivity of the solution being measured. Cell calibration may also be affected by

electrode fouling, replatinization, or by mechanical shock. A cell and meter can be calibrated together, as a system, with YSI 3160-3169 Conductivity Calibrator Solutions.

YSI Conductivity Calibrator Solutions are supplied with a full technical discussion and detailed instructions for use.

Part Number	Size	Conductivity at 25.00 degrees C
YSI 3160	Gallon	1000 micromho/cm $\pm 0.50\%$
YSI 3161	Quart	1000 micromho/cm $\pm 0.50\%$
YSI 3162	Gallon	10,000 micromho/cm $\pm 0.25\%$
YSI 3163	Quart	10,000 micromho/cm $\pm 0.25\%$
YSI 3164	Gallon	100,000 micromho/cm $\pm 0.25\%$
YSI 3165	Quart	100,000 micromho/cm $\pm 0.25\%$
YSI 3167	8 Pints	1000 micromho/cm $\pm 1\%$
YSI 3168	8 Pints	10,000 micromho/cm $\pm 1\%$
YSI 3169	8 Pints	50,000 micromho/cm $\pm 1\%$

Directions for calibration at temperatures other than 25°C are included with the Conductivity Calibrator Solutions.

In calculating the cell constant in absolute terms, the uncertainty of the meter calibration must be added to the tolerance of the Conductivity Calibrator Solution.

YSI MODEL 33 AND 33M USED WITH YSI 51A, 54, 57 AND 58 OXYGEN METERS

If the salinity measurement is to be used for salinity correction on the 51A, the reading should be converted to Chlorosity. The formula is:

$$\text{PPH Chlorosity} = [(\text{Salinity ppt} - 0.03) / (1.8)] \times 10^3$$

For these instruments the 0.03 can be neglected so the equation simplifies to:

$$\text{PPH/Cl} = (\text{salinity in ppt} \times 10^3) / 1.8$$

For salinity correction when using the Model 57 or 58, use the salinity reading direct from the Model 33 or 33M. No conversion is necessary.

Model 33 and 33M salinity readings taken in conjunction with Model 54 dissolved oxygen readings can be used to correct the Model 54 for salinity and to make post-measurement salinity corrections to dissolved oxygen data. Correction tables are available from the factory.

WARRANTY

All YSI products carry a one-year warranty on workmanship and parts, exclusive of batteries. Damage through accident, misuse, or tampering will be repaired at a nominal charge.

If you are experiencing difficulty with any YSI product, it may be returned to an authorized YSI dealer for repair, even if the warranty has expired. If you need factory assistance for any reason, contact:

Product Service Department
Yellow Springs Instrument Co., Inc.
1725 Brannum Lane
P.O. Box 279
Yellow Springs, Ohio 45387, U.S.A.
Phone: (513) 767-7241 (800) 343-HELP



YSI Scientific

Yellow Springs, Ohio 45387 USA • Phone 513 767-7241 • 800 343-HELP

ATTACHMENT B

Delete
For
Fund-lead
Only

SAMPLE CUSTODY PROCEDURES

INTRODUCTION

It is U.S. EPA and Region V policy to follow the U.S. EPA Region V sample custody or chain of custody protocols as described in "NEIC Policies and Procedures," EPA-330/9-78-001-R, revised June 1985. This custody is in three parts: sample collection, laboratory, and final evidence files. Final evidence files, including all originals of laboratory reports and purge files, are maintained under document control in a secure area.

A sample or evidence file is under your custody if the documents

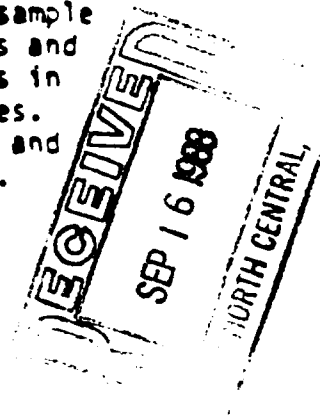
- are in your possession;
- are in your view, after being in your possession;
- were in your possession and you placed them in a secured location; or
- are in a designated secure area.

FIELD SPECIFIC CUSTODY PROCEDURES

The sample packaging and shipment procedures summarized below will insure that the samples will arrive at the laboratory with the chain of custody intact.

Field procedures are as follows:

- (a) The field sampler is personally responsible for the care and custody of the samples until they are transferred or properly dispatched. As few people as possible should handle the samples.
- (b) All bottles will be tagged with sample numbers and locations. The Sample Management Office (SMO) number and stickers will be affixed.
- (c) Sample tags are to be completed for each sample using waterproof ink unless prohibited by weather conditions. For example, a logbook notation would explain that a pencil was used to fill out the sample tag because the ballpoint would not function in freezing weather.
- (d) The contractor's site manager must review all field activities to determine whether proper custody procedures were followed during the field work and decide if additional samples are required. He or she should notify the U.S. EPA Remedial Project Manager of a breach or irregularity in chain of custody procedures.



Transfer of custody and shipment procedures are as follows:

- (a) Samples are accompanied by a properly completed chain of custody form. The sample numbers and locations will be listed on the chain of custody form. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the record. This record documents transfer of custody of samples from the sampler to another person, to a mobile laboratory, to the permanent laboratory, or to/from a secure storage area.
- (b) Samples will be properly packaged for shipment and dispatched to the appropriate laboratory for analysis, with a separate signed custody record enclosed in each sample box or cooler. Shipping containers will be locked and secured with strapping tape and EPA custody seals for shipment to the laboratory. The preferred procedure includes use of a custody seal attached to the front right and back left of the cooler. The custody seals are covered with clear plastic tape. The cooler is strapped shut with strapping tape in at least two locations.
- (c) Whenever samples are split with a source or government agency, a separate Sample Receipt is prepared for those samples and marked to indicate with whom the samples are being split. The person relinquishing the samples to the facility or agency should request the representative's signature acknowledging sample receipt. If the representative is unavailable or refuses, this is noted in the "received by" space.
- (d) All shipments will be accompanied by the Chain of Custody Record identifying the contents. The original record will accompany the shipment, and the pink and yellow copies will be retained by the sampler for return to the sampling office.
- (e) If the samples are sent by common carrier, a bill of lading should be used. Receipts of bills of lading will be retained as part of the permanent documentation. If sent by mail, the package will be registered with return receipt requested. Commercial carriers are not required to sign off on the custody form as long as the custody forms are sealed inside the sample cooler and the custody seals remain intact.

LABORATORY CUSTODY PROCEDURES

a. CONTRACT LABORATORY

The chain of custody procedures for Contract Laboratory Program (CLP) are described in the SOWs for RASs. This same custody procedure applies to SASS. These custody procedures along with the holding time requirements for CLP samples are described in the appropriate SOW documents.

CENTRAL REGIONAL LABORATORY CHAIN OF CUSTODY

The Central Regional Laboratory has its own regional custody scheme for Drinking Water Specific Samples.

There are four possible ways in which the CRL may be involved in chain of custody sample tracking:

- A. Samples are delivered to the CRL for in-house analysis.
- B. Samples are delivered to the CRL. Some are sent out to a contractor and some remain at the CRL, or the samples are sent to several contract laboratories.
- C. Samples are delivered to the CRL and the entire shipment is sent to one contract laboratory.
- D. Samples are shipped directly from the field to a contract laboratory without ever being delivered to the CRL.

The internal CRL Custody Protocol has been revised so that it addresses all four of these situations and also meets all National EPA custody requirements. Moreover, the revised protocol requires only one new internal document - the Custody Logbook. This logbook replaces the existing Shipping and Receiving Log. The new procedure is applied to the four custody situations as follows.

A. In-House Analysis

Samples are shipped or delivered to the CRL under chain of custody. The CRL Sample Custodian signs the Chain of Custody Record (see Figure 4-1) in the "Received by" space. The Sample Custodian also signs in the "Received for Laboratory by" space. This document is then complete. It is filed in the folder for the given data set.

The Sample Custodian then enters the following sample information into the Custody Logbook (see Figure 4-2).

1, 2, 3 - Self-explanatory.

4 - "Matrix" refers to a brief sample description, such as "water," "oil," "mud," etc. Parameter is self-explanatory.

5 - Self-explanatory.

6,7,8 - The Sample Custodian initials the date (month/day/year) and the time when samples were received. Time is expressed using a 24-hour clock, so that 1:30 P.M. is recorded as 13:30.

9 - Each shelf in all custody areas should be numbered, so that the storage location can be identified by the shelf number. This number is entered in column 9.

When an analyst checks out a sample, columns 10 thru 13 are completed.

10 - The Sample Custodian initials the correct column.

11 - The analyst initials the correct column.

12, 13 - The Sample Custodian enters the date and time.

When a sample is transferred from one analyst to another within the CRL, both analysts initial the back of the custody tag. They also enter the date and time.

e.g.,: AJ to DM, 9/12/82, 15:30

(It is not necessary to return the sample to the person who originally checked it out of custody.)

Figure 4-1 CHAIN OF CUSTODY FORM (CRL #1)

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:

When the analyses are completed, the analyst returns the sample to the Sample Custodian. They both fill in columns 14 thru 18.

14, 15, 16, 17 - Self-explanatory.

18. - The Sample Custodian stores the sample in a custody area. The location is entered in column 18. This is probably not the same as the original location listed in column 9.

When samples are discarded, columns 19 and 20 are filled in. The tags are removed from the sample bottles and are filed in the folder for that data set. TAGS ARE NEVER DISCARDED.

Any appropriate information, including initials, is entered in column 21.

e.g., : "Sample was broken. 10/1/82, AJ"
"Sample was used up. 10/1/82, AJ"
"Insufficient sample. 10/1/82, AJ"

Even if a sample is destroyed, the tag must be returned to the custody folder. An explanation should be written on the tag and in the Custody Logbook.

B. Sample Shipments With Several Destinations

Samples are shipped to the CRL under chain of custody. The CRL Sample Custodian receives the shipment as described in Section A. The Custodian opens the sealed container, logs in all of the samples, and then repacks those samples which will be sent to a contract laboratory. The Custodian fills out new custody forms and includes them with the shipment as described in the Environmental Services Division (ESD) or National Contract Laboratory Protocols.

The Sample Custodian logs all of the samples into the Custody Logbook. The procedure is the same as described in Section A, with the following exceptions.

- 9 - No entry here.
- 10 - The Sample Custodian initials here.
- 11 - The Sample Custodian enters the name of the laboratory to which the samples were shipped.
- 14 thru 20 - These columns are used only if the contract laboratory returns the samples.
- 21 - The Sample Custodian enters the shipper and the airbill number.

e.g.,: "Emery, #9011625"

C. Entire Sample Shipment Sent to One Destination

Samples are shipped to the CRL under chain of custody. The CRL Sample Custodian receives the samples. The Custodian signs the chain of custody record in the "Received by" space. The Custodian logs in the samples and then packs them for shipment and includes original the chain of custody record with the samples. The custodian does not sign the "Received for Laboratory by" space (see Figure 4-3).

The Sample Custodian logs all of the samples into the Custody Logbook as described in Section B.

D. Samples Shipped From the Field to Contract Laboratories

When samples are shipped directly from the field to a contract laboratory, no one at the CRL signs the chain of custody Record.

The sampling team submits a report to the CRL describing their sampling activities. The Sample Custodian enters that information into the Custody Logbook as follows:

1 thru 4 - Self-explanatory.

5 - Tag numbers may not be available in the field report.

6 thru 9 - Not applicable.

10 - The Sample Custodian enters "field."

11 - The Sample Custodian enters the name of the laboratory to which the samples were sent.

12, 13 - Shipping date and time are entered, if available.

14 thr 20 - These columns are used only if the samples are sent to the CRL by the contract laboratory.

21 - Shipper, airbill number, and any other comments are entered here.

The purge files from the Contract Laboratory Program (CLP) are maintained by Region V CRL Laboratory Support Team, Data Coordinator, and CPMS.



FIT maintains the SI files along with all relevant records, PA/SI reports, safety reports, logs, field notebooks, pictures, subcontractor reports, and CPMS data reviews for the specific site held in a secured, limited access area and under custody of the FIT-DCC.

Figure 4-3 CHAIN OF CUSTODY FORM (CRL #2)


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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

NATIONAL ENFORCEMENT INVESTIGATIONS CENTER
 Building 33, Box 25227, Denver Federal Center
 Denver, Colorado 80225

Field Code	Station No.	Monitor Location	Time	Designate		
				Cont	Grid	
N-1301	Station Description	Sampler's Signature			Procedural: Yes <input type="checkbox"/> No <input type="checkbox"/>	
					ANALYSES	
Lab Sample No.	Microbials	BOD Antec				
		BOD 15/18/25/35/45				
		COD TOC				
		Mutitox DAC				
		Phenolics				
		Metals				
		Cyanide				
		Benz Valatol				
		Organics				
		Valatolite Organics				
Pesticides PCBs						
ACCA Characteristic						
ACCA listed waste						



only 1 year, average was 1.4 days) resulting in substantial (30 percent) cost savings

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FINAL EVIDENCE FILES CUSTODY PROCEDURES

The final evidence files from the CRL and Contract Laboratory Program (CLP) are maintained by Region V CRL Laboratory Support Team, Data Coordinator.

The contractor maintains the RI files along with all relevant records, reports, logs, field notebooks, pictures, subcontractor reports and CPMS data reviews in a secured, limited access area and under custody of the contractor's site manager.

ATTACHMENT C

United States
Environmental Protection
Agency

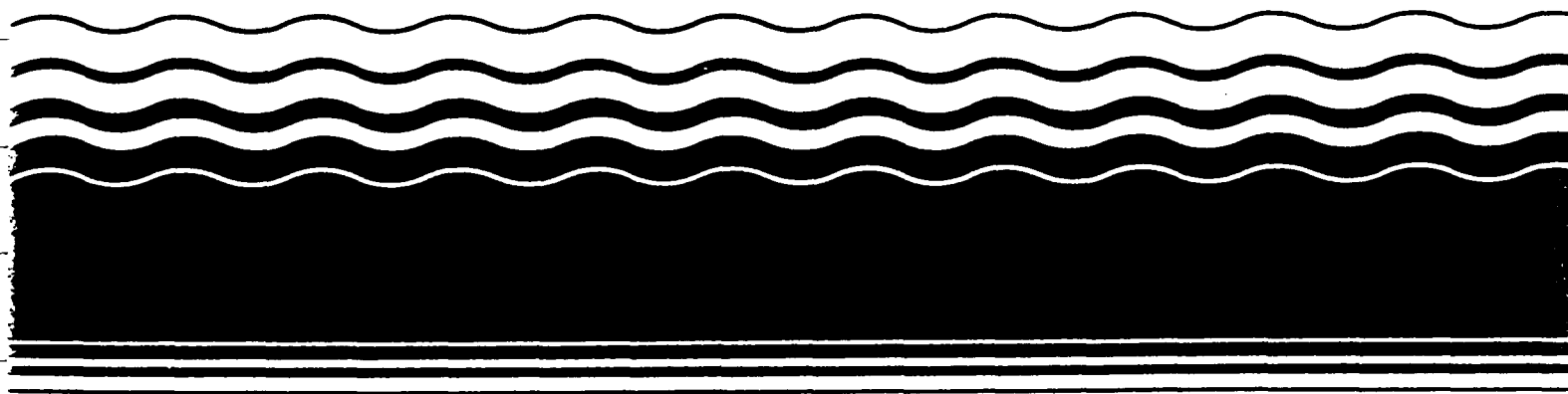
Office of Emergency and
Remedial Response
Washington DC 20460

EPA/540/P-87/001
(OSWER Directive 9355.0-14)
December 1987

Superfund



A Compendium of Superfund Field Operations Methods



5. A 10- to 20-minute stabilization period may be required because the carrier gas flow is temporarily interrupted when the septum is changed.

15.1.6.8 Troubleshooting

A list of common troubleshooting techniques for the Photovac 10A10 is provided in Exhibit 15-3.

15.1.7 Region-Specific Variances

No region-specific variances have been identified; however, all future variances will be incorporated in subsequent revisions to this compendium. Information on variances may become dated rapidly. Thus, users should contact the regional EPA RPM for full details on current regional practices and requirements.

15.1.8 Information Sources

Horgan, L. Proposed Guidelines for Photovac 10A10 for the Surveillance and Analysis Division. U.S. Environmental Protection Agency. 1983.

Photovac Incorporated. *Photovac 10A10 Operating Manual*.

15.2 HNU PI-101

15.2.1 Purpose

Subsection 15.2 discusses the use, maintenance, and calibration of the HNU PI-101.

15.2.2 Definitions

None.

15.2.3 Theory and Limitations

15.2.3.1 Theory

The HNU is a portable, nonspecific, vapor / gas detector employing the principle of photolionization to detect a variety of chemical compounds, both organic and inorganic.

The HNU contains an ultraviolet (UV) light source within its sensor chamber. Ambient air is drawn into the chamber with the aid of a small fan. If the ionization potential (IP) of any molecule present in the ambient air is equal to or lower than the energy of the UV light source, ionization will take place, causing a deflection in the meter. Response time is approximately 90 percent at 3 seconds. The meter reading is expressed in parts per million (ppm). All readings must be stated as equivalent readings that depend on the calibration gas being used. For example, the standard gas used to calibrate the HNU is benzene, which allows the instrument to provide results in benzene equivalence. Exhibit 15-4, modified from the *Instruction*

Manual for Model PI-101 Photoionization Analyzer HNU Systems Inc., 1975, lists the relative sensitivities for various gases.

15.2.3.2 Limitations

1. If the IP of a chemical contaminant is greater than the UV light source, this chemical will not be recorded. Some contaminants cannot be determined by any sensor / probes.
2. It should be noted, specifically, that the HNU will not detect methane.
3. During cold weather, condensation may form on the UV light source window, resulting in erroneous results.
4. Instrument readings can be affected by humidity and powerlines, making it difficult to interpret readings.
5. Total concentrations are relative to the calibration gas (usually benzene) used. Therefore, true contaminants and their quantities cannot be identified. Also, while the instrument scale reads 0 to 2,000 ppm, response is linear (to benzene) from 0 to about 600 ppm. Greater concentrations may be "read" at a higher or lower level than the true value.
6. Wind speeds of greater than 3 miles an hour may affect fan speed and readings, depending on the position of the probe relative to wind direction.

15.2.4 Applicability

This procedure is applicable to HNU PI-101 instruments used for air monitoring.

15.2.5 Responsibilities

The SM is responsible for monitoring the implementation of these procedures.

15.2.6 Records

Training records, maintenance records, and calibration records will be generated and maintained by the responsible organization. The maintenance, calibration, and results obtained in the field will be recorded in the site logbook.

15.2.7 Procedure

15.2.7.1 Maintenance and Calibration Responsibilities

The instrument user is responsible for properly calibrating and operating the instrument. When the instrument is scheduled for or requires maintenance, these functions should be conducted only by qualified individuals. If possible, maintenance responsibilities should be restricted to one or two individuals who will also bear responsibilities for logging the equipment in and out. Documentation of instrument user, dates of

Exhibit 15-4
RELATIVE SENSITIVITIES FOR VARIOUS GASES
(10.2 eV Lamp)

Species	Photoionization Sensitivity*
P-xylene	11.4
M-xylene	11.2
Benzene	10.0 (reference standard)
Toluene	10.0
Diethyl sulfide	10.0
Diethyl amine	9.9
Styrene	9.7
Trichloroethylene	8.9
Carbon disulfide	7.1
Isobutylene	7.0
Acetone	6.3
Tetrahydrofuran	6.0
Methyl ethyl ketone	5.7
Methyl isobutyl ketone	5.7
Cyclohexanone	5.1
Naptha (86% aromatics)	5.0
Vinyl chloride	5.0
Methyl isocyanate	4.5
Iodine	4.5
Methyl mercaptan	4.3
Dimethyl sulfide	4.3
Allyl alcohol	4.2
Propylene	4.0
Mineral spirits	4.0
2,3-Dichloropropene	4.0
Cyclohexene	3.4
Crotonaldehyde	3.1
Acrolein	3.1
Pyridine	3.0
Hydrogen sulfide	2.8
Ethylene dibromide	2.7
N-octane	2.5
Acetaldehyde Oxime	2.3

**Exhibit 15-4
(continued)**

Species	Photolioniztion Sensitivity*
Hexane	2.2
Phosphine	2.0
Heptane	1.7
Allyl chloride	
(3-chloropropene)	1.5
Ethylene	1.0
Ethylene oxide	1.0
Acetic anhydride	1.0
Alpha pinene	.07
Dibromochloropropane	0.7
Epichlorohydrin	0.7
Nitric oxide	0.6
Beta pinene	0.5
Citral	0.5
Ammonia	0.3
Acetic Acid	0.1
Nitrogen dioxide	0.02
Methane	0.0
Acetylene	0.0
Ethylene	0.0

*Expressed in ppm (v/v).

Source: *Instruction Manual for Model PI-101*
Photoionization Analyzer, HNU Systems, Inc., 1975.

use, instrument identification number, maintenance and calibration functions, and project identification should be maintained.

15.2.7.2 Operator Qualifications

The HNU, although a relatively simple instrument to use, can be incorrectly operated if the user is not thoroughly familiar with its operation. An appropriate training and certification procedure must be developed and incorporated into the responsible organization's training procedures. The users must complete the training and be certified for HNU operation before using the instrument in the field. Refresher courses should be obligatory every 6 months. Courses are given by the manufacturer, by commercial entities, and by EPA at their Cincinnati, Ohio, and Edison, New Jersey, facilities.

15.2.7.3 Startup / Shutdown Procedures

Startup

1. Check the FUNCTION switch on the control panel to make sure it is in the OFF position. Attach the probe to the readout unit. Match the alignment key, and twist the connector clockwise until a distinct locking is felt.
2. Turn the FUNCTION switch to the BATTERY CHECK position. Check that the indicator reads within or beyond the green battery arc on the scale plate. If the indicator is below the green arc, or if the red LED comes on, the battery must be charged before using.
3. To zero the instrument, turn the FUNCTION switch to the STANDBY position and rotate the ZERO POTENTIOMETER until the meter reads zero. Wait 15 to 20 seconds to confirm that the zero adjustment is stable. If it is not, then readjust.
4. Check to see that the SPAN POTENTIOMETER is set at the appropriate setting for the probe being used (5.0 for 9.5 eV probe, 9.8 for 10.2 eV, and 5.0 for 11.7 eV).
5. Set the FUNCTION switch to the desired ppm range. A violet glow from the UV lamp source should be observable at the sample inlet of the probe / sensor unit. (Do not look directly at the glow, since eye damage could result.)
6. Listen for the fan operation to verify fan function.
7. Check instrument with an organic point source, such as a "magic marker," before survey to verify instrument function.

Shutdown

1. Turn FUNCTION switch to OFF.
2. Disconnect the probe connector.
3. Place the instrument on the charger.

15.2.7.4 Maintenance and Calibration Schedule

<u>Function</u>	<u>Frequency</u>
• Perform routine calibration	Prior to each use*
• Initiate factory checkout and calibration	Yearly or when malfunctioning or after changing UV light source
• Wipe down readout unit	After each use
• Clean UV light source window	Every month or as use and site conditions dictate
• Clean the ionization chamber	Monthly
• Recharge battery	After each use

* During extended field use, the HNU PI-101 must be calibrated at least once every three days.

15.2.7.5 Calibration Procedure No. 1

For HNU calibration canisters without regulators:

1. Run through startup procedures as in Subsection 15.2.7.3.
2. Fill a sampling bag with HNU calibration gas of known contents.
3. Connect HNU probe to sampling bag by using flexible tubing.
4. Allow sample bag contents to be drawn into the probe, and check response in ppm.
5. Adjust the span potentiometer to produce the concentration listed on the span gas cylinder. This procedure shall be followed only until the span potentiometer reaches the following limits:

<u>Probe</u>	<u>Initial Span Pot. Setting</u>	<u>Maximum Acceptance Span Pot. Setting</u>
9.5 eV	5.0	1.0
10.2 eV	9.8	8.5
11.7 eV	5.0	2.0

6. If these limits are exceeded, the instruments must be returned for maintenance and recalibration. This maintenance will be done only by qualified individuals.

7. Each responsible organization must develop a mechanism for the documentation of calibration results. This documentation includes the following:

- a. Date Inspected
- b. Person who calibrated the instrument
- c. The instrument number (Serial number or other ID number)
- d. The results of the calibration (ppm, probe eV, span potentiometer setting)
- e. Identification of the calibration gas (source, type, concentration)

15.2.7.6 Calibration Procedure No. 2

For HNU calibration canisters equipped with a regulator:

1. Run through startup procedures as described in Subsection 15.2.6.3.
2. Connect a sampling hose to the regulator outlet and the other end to the sampling probe of the HNU.
3. Crack the regulator valve.
4. Take a reading after 5 to 10 seconds.
5. Adjust span potentiometer using the steps outlined in step No. 5 of Subsection 15.2.7.5.
6. Calibration documentation should be as in step No. 7 in Subsection 15.2.7.5.

15.2.7.7 Cleaning the UV Light-Source Window

1. Turn the FUNCTION switch to the OFF position, and disconnect the sensor / probe from the Readout / Control unit.
2. Remove the exhaust screw located near the base of the probe. Grasp the end cap in one hand and the probe shell in the other. Separate the end cap and lamp housing from the shell.
3. Loosen the screws on the top of the end cap, and separate the end cap and ion chamber from the lamp and lamp housing, taking care that the lamp does not fall out of the lamp housing.
4. Tilt the lamp housing with one hand over the opening so that the lamp slides out of the housing into your hand.
5. The lamp window may now be cleaned using lens paper with any of the following compounds:
 - a. Use HNU Cleaning Compound on all lamps except the 11.7 eV.

b. Clean the 11.7 eV lamp with a freon or chlorinated organic solvent. Do not use HNU cleaner, water, or water miscible solvents (i.e., acetone and methanol).

6. Following cleaning, reassemble by first sliding the lamp back into the lamp housing. Place the ion chamber on top of the housing, making sure the contacts are properly aligned.

7. Place the end cap on top of the ion chamber, and replace the two screws. Tighten the screws only enough to seal the O-ring. Do not overtighten.

8. Line up the pins on the base of the lamp housing with pins inside the probe shell, and slide the housing assembly into the shell. It will fit only one way.

9. Replace the exhaust screw.

15.2.7.8 Cleaning the Ionization Chamber

1. Turn the FUNCTION switch to the OFF position, and disconnect the sensor/probe from the Readout / Control unit.

2. Remove the exhaust screws located near the base of the probes. Grasp the end cap in one hand and the probe shell in the other. Separate the end cap and lamp housing from the shell.

3. Loosen the screws on the top of the end cap, and separate the end cap and ion chamber from the lamp and lamp housing, taking care that the lamp does not fall out of the lamp housing.

4. The ion chamber may now be cleaned according to the following sequence:

a. Clean with methanol using a Q-tip.

b. Dry gently at 50°C to 60°C for 1/2 hour.

5. Place the ion chamber on top of the housing, making sure the contacts are properly aligned.

6. Place the end cap on top of the ion chamber and replace the two screws. Tighten the screws only enough to seal the O-ring. Do not overtighten.

7. Line up the pins on the base of the lamp housing with pins inside the probe shell, and slide the housing assembly into the shell. It will fit only one way.

15.2.7.9 Troubleshooting

The following steps should be performed only by a qualified technician:

1. The meter does not respond in any switch position (including BATT CHK).

a. Meter movement is broken.

- (1) Tip instrument rapidly from side to side. Meter needle should move freely and return to zero.
 - b. Electrical connection to meter is broken
 - (1) Check all wires leading to meter.
 - (2) Clean the contacts of quick-disconnects.
 - c. Battery is completely dead.
 - (1) Disconnect battery.
 - (2) Check voltage with a volt-ohm meter.
 - d. Check 2 mp fuse.
 - e. If none of the above solves the problem, consult the factory.
2. Meter responds in BATT CHK position, but reads zero or near zero for all others.
- a. Power supply is defective.
 - (1) Check power supply voltages as shown in Figure 11 of the HNU *Instruction Manual*. If any voltage is out of specification, consult the factory.
 - b. Input transistor or amplifier has failed.
 - (1) Rotate zero control; meter should deflect up or down as control is turned.
 - (2) Open probe. Both transistors should be fully seated in sockets.
 - c. Input signal connection is broken in probe or readout.
 - (1) Check input connector on printed circuit board. The input connector should be firmly pressed down.
 - (2) Check components on back of printed circuit board. All connections should be solid, and no wires should touch any other object.
 - (3) Check all wires in readout for solid connections.
3. Instrument responds correctly in BATT CHK and STBY but not in measuring mode.
- a. Check to see that the light source is on. Do not look directly at UV light source, since eye damage could result.
 - (1) Check high-voltage power supply.

(2) Open end of probe, remove lamp, and check high voltage on lamp ring.

(3) If high voltage is present at all above points, light source has probably failed. Consult the factory.

4. Instrument responds correctly in all positions, but signal is lower than expected.

- a. Check span setting for correct value.
- b. Clean window of light source.
- c. Double check preparation of standards.
- d. Check power supply 180 V output.
- e. Check for proper fan operation. Check fan voltage.
- f. Rotate span setting. Response should change if span potentiometer is working properly.

5. Instrument responds in all switch positions, but is noisy (erratic meter movement).

- a. Open circuit in feedback circuit. Consult the factory.
- b. Open circuit in cable shield or probe shield. Consult the factory.

6. Instrument response is slow and/or irreproducible.

- a. Fan is operating improperly. Check fan voltage.
- b. Check calibration and operation.

7. The battery indicator is low.

- a. Indicator comes on if battery charge is low.
- b. Indicator also comes on if ionization voltage is too high.

15.2.8 Region-Specific Variances

No region-specific variances have been identified; however, all future variances will be incorporated in subsequent revisions to this compendium. Information on variances may become dated rapidly. Thus, users should contact the regional EPA RPM for full details on current regional practices and requirements.

15.2.9 Information Sources

HNU Systems, Inc. *Instruction Manual for Model PI-101 Photoionization Analyzer*. 1975.

Ecology and Environment. *FIT Operation and Field Manual: HNU Systems PI-101 Photoionization Detector and Century Systems (Foxboro) Model OVA-128 Organic Vapor Analyzer*. 1981.

Personal Communication with Fran Connel, HNU Systems, Inc. 4 January 1984.

CH2M HILL. *Field Surveillance Equipment*. 1984.

Rabin, Linda J. "Selective Application of Direct-Reading Instruments at Hazardous Waste Sites," presented at American Industrial Hygiene Conference, Dallas, Texas. 1986.

15.3 ORGANIC VAPOR ANALYZER (OVA-128)

15.3.1 Scope and Purpose

The purpose of this subsection is to discuss the use, maintenance, and calibration of the OVA-128.

15.3.2 Definitions

None.

15.3.3 Theory and Limitations

15.3.3.1 Theory

The OVA uses the principle of hydrogen flame ionization for the detection and measurement of organic compounds. The OVA contains a diffusion flame of hydrogen and air that is free of ions and is nonconducting. When a sample of organic material is introduced into the flame, ions are formed, causing the flame to become conductive. Eventually this conductivity provides a meter reading because of a change in current.

15.3.3.2 Limitations

1. The OVA will not see any inorganics.
2. The OVA will "see" methane, which is explosive but relatively nontoxic. The user should determine if the contaminant involved is or is not methane.
3. DOT shipping regulations are strict for the OVA when shipped containing pressurized hydrogen.
4. A relative humidity greater than 95 percent will cause inaccurate and unstable responses.

APPENDIX A-3
WATER LEVEL MEASUREMENTS/WATER SAMPLING

Water level measurement prior to ground water sampling will be made with the Solinst Model 101 flat tape water level meter.

Equipment for the measurement of pH, specific conductance, temperature, and field filtration of ground water samples associated with water sampling for the Stoughton City Landfill site have not been purchased to date. Upon purchase, operation manuals or instructions for the various meters and apparatus will be sent to the USEPA and WDNR. These instruments will be operated in accordance with the manufacturers' specifications.

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APPENDIX A-4

AIR SAMPLING

Major sampling equipment associated with air sampling will be wind direction/wind speed instrumentation and a sampling pump. Wind speed/direction will be measured using the Weathertronics, Inc. combination wind speed/direction sensor. This sensor will be mounted atop a ten-foot portable tower. The attached sheet lists specifications of the combination wind speed/direction sensor.

A Gilian Model HFS-113A sampling pump will be utilized to collect the air sample. This sampling pump features a low flow operating range required for use during the RI.3

COMBINATION WIND SPEED/DIRECTION SENSOR

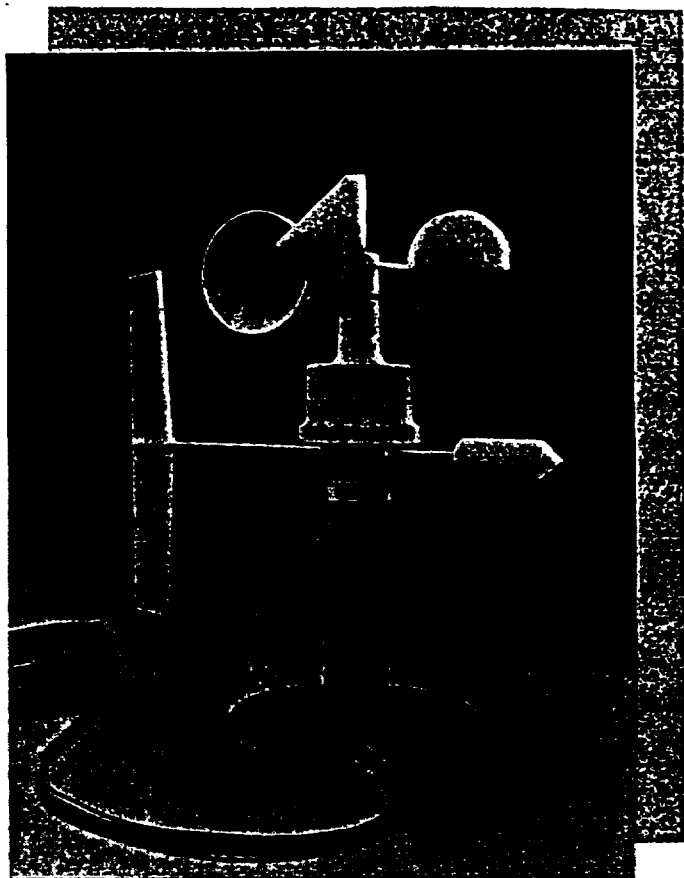
- Low cost wind monitoring
- Rugged materials
- Easy to install
- Separate vane and anemometer available

The Model 2132 wind sensor is designed for applications where accuracy is not critical and cost is a consideration. This is a combination wind speed and direction sensor, with a 3-cup anemometer and an airfoil vane mounted on a common vertical axis. All major structural components are fabricated from tough polycarbonate or anodized aluminum. The sensor includes a mounting collar for simple and direct mounting to a 3/4-inch (19 mm) O.D. mast (Model 85007). A 50-foot length of signal cable is provided. Up to 500 feet of cable can be used.

The cup assembly of the anemometer is coupled to an AC generator transducer. The generator produces an output voltage which is directly proportional to wind speed. The measuring range is 0 to 100 mph (0 to 45 m/s) with an accuracy of $\pm 3\%$. The lightweight vane is attached to a long-life, conductive plastic potentiometer. Rotation of the vane moves a precious metal wiper to produce an output voltage corresponding to the vane position within the 0 to 360° range.

Both the anemometer and the vane can also be purchased separately for applications that require measurement of only wind speed or wind direction. The Model 2612 anemometer and the Model 2134 vane both include 50 feet of cable and mount directly to a 3/4-inch (19 mm) O.D. mast.

All three of these sensors are excellent for home use, office or lobby displays, or school weather stations.



ORDERING INFORMATION

Model 2132	Combination Wind Speed and Direction Sensor; includes 50' of 5-conductor flat cable
2132-A	Same as 2132 except with 100' of 5-conductor flat cable
2134	Wind Direction Sensor only; includes 50' of 3-conductor flat cable
2612	Wind Speed Sensor only; includes 50' of 2-conductor flat cable
85007	Vertical Mast to mount 2132 on Model 8500 tripod tower; 5' long X 1.5" O.D.; includes reducer to 3/4" O.D.
T600802	Additional 2-conductor flat cable
T600803	Additional 3-conductor flat cable
T600806	Additional 5-conductor flat cable

NOTE: This instrument was formerly known as Model W200-SD in the WeatherMeasure line.

SPECIFICATIONS

Wind Speed:	
Sensor	3-cup assembly, polycarbonate, 2.7" dia. cups
Transducer	AC generator
Output	10.70 VAC nominal at 100 mph
Range	0-100 mph (0-45 m/s)
Accuracy	$\pm 3\%$
Wind Direction:	
Sensor	Counterbalanced airfoil vane
Transducer	500-ohm plastic potentiometer
Range	0-360°
Accuracy	$\pm 5\%$
Input voltage	5 VDC typical
Materials	Anodized aluminum and polycarbonate
Mounting	Direct to 3/4" (19 mm) O.D. mast
Cable	5-conductor flat, 50' (15.2 m) supplied, 500' max.
Size	6.25" H X 16" L (159 X 406 mm), 10.5" (267 mm) turning radius
Weight/shipping	1.5 lbs./4 lbs. (0.7 kg/1.8 kg)